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Publication 1477/E

Lowbush blueberry production

Canada

CHECKLIST

To maximize lowbush blueberry production and yield

- Select fields where wild blueberry plants already grow.
- Develop fields that are relatively level and contain few large boulders and weeds.
- Encourage best growth by burning late in the fall or early in the spring.
- Learn the common weeds, insects, and diseases and apply appropriate control measures at the proper time of year.
- Apply fertilizers based on soil and tissue sample test results correlated with data on crop yield over several cycles.
- Supplement native bees with honeybees if you have low fruit set.
- Control bruising and physical damage to the blueberries during harvest.
- Cool harvested blueberries to 0°C as quickly as possible.

Lowbush blueberry production

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Recommendations for pesticide use in this publication are intended as guidelines only. Any application of a pesticide must be in accordance with directions printed on the product label of that pesticide as prescribed under the *Pest Control Products Act*. **Always read the label.** A pesticide should also be recommended by provincial authorities. Because recommendations for use may vary from province to province, your provincial agricultural representative should be consulted for specific advice.

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PRODUCTION AND MANAGEMENT

C.R. Blatt and I.V. Hall

INTRODUCTION

Production of lowbush blueberries in Canada is confined almost entirely to eastern Canada, where, because they are part of the native vegetation, blueberries are well adapted to the temperate climate. The largest area of blueberry land has been developed from abandoned or run-out farmland, particularly in Nova Scotia and New Brunswick. Many blueberry fields in Quebec formerly supported stands of jack pine.

Although most lowbush blueberries are processed, a small but increasing percentage is marketed as fresh fruit. The fruit is very popular as a pie filler or as a supplement to muffin and pancake mixes.

From 1974 to 1978, production of lowbush blueberries in the five eastern provinces varied between 7146 t (in 1974) and 12 051 t (in 1977) (Table 1). Production in the State of Maine, the only other large producing area in the world, equals the annual Canadian yield in some years. In the last 10 years since the introduction of herbicides and fertilizers as standard management practices, lowbush blueberry production has increased dramatically. Total production from these five provinces ranged from 9230 t (in 1980) to 23 537 t (in 1988); the State of Maine has also recorded substantial increases in yield (Table 1).

CLASSIFICATION OF BLUEBERRY PLANTS

Five kinds of blueberries grow wild in Canada. Four are lowbush types and the other is a highbush type. The fruits of all, with the possible exception of ground hurts, are harvested and sold commercially.

Velvet-leaf blueberry (*Vaccinium myrtilloides* Michx.)

This species can be distinguished by its hairy leaves and stems and nontoothed margins of the leaves. It is the blueberry most commonly found in woodlands and is the most abundant species in blueberry fields recently developed from woods. It is usually eliminated by repeated burning. The range of velvet-leaf blueberry is from Nova Scotia to Vancouver Island.

Ground hurts (*Vaccinium boreale* Hall & Alders)

The stems of this species are much branched, and the plant grows along the ground. It is most abundant on exposed headlands in Newfoundland but is rarely found elsewhere in Canada.

Table 1 Commercial production of lowbush blueberries

	Yield (t)														
Location	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Nova Scotia	3 428	4 504	3 104	3 721	5 270	4 864	3 787	5 836	6 402	8 846	6 853	8 596	7 354	6 135	9 980
Newfoundland	300	1 448	499	1 660	649	1 203	199	237	1 023	633	139	145	755	2 591	1 123
Prince Edward Island	318	363	363	340	386	227	256	272	340	363	318	340	227	414	642
New Brunswick	1 263	1 740	1 706	1 499	1 678	1 941	1 769	2 313	3 493	3 842	1 980	2 359	2 722	3 175	4 082
Quebec	1 837	3 402	2 359	4 831	2 889	3 080	3 219	6 350	5 670	3 379	3 118	3 965	460	8 980	7 710
Maine	8 429	5 407	11 308	6 524	8 399	7 972	9 616	8 618	16 295	20 255	11 196	19 836	18 221	16 479	23 773

Sources: Fruit and vegetable production, December 1980, December 1983, December 1985, and May 1988, Statistics Canada, Cat. No. 22-003. Production figures for Nova Scotia taken from "Lowbush blueberry production and marketing in Nova Scotia, a situation report—1988," prepared by J.D. Sibley. Production figures for Maine supplied by J.D. Sibley.

Common lowbush blueberry (*Vaccinium angustifolium* Ait.)

This kind has shiny, smooth leaves with toothed margins, the points of which bear minute glands. It is the most abundant type of blueberry in stands developed on abandoned hayfields and in other fields that have been burned for many years. The range of this species is from Newfoundland to Manitoba.

Black lowbush blueberry (*Vaccinium angustifolium* f. *nigrum* (Wood) Boivin)

This type can be distinguished by its blue green leaves and black, shiny berries. In range and habitat it is similar to the common lowbush blueberry except that it usually increases more rapidly with repeated burning.

Highbush blueberry (*Vaccinium corymbosum* L.)

The foliage and stems of this species are extremely variable in size, but typical plants are 1–3 m high. It crosses freely with the common lowbush blueberry and in certain areas a complex of intermediate and parental types is found. Its range is from Nova Scotia to Ontario, and it grows mostly in or around the edges of bogs or swampy areas.

The velvet-leaf and ground hurts are both diploid species (24 chromosomes), whereas the other two lowbush types and the highbush species are tetraploid (48 chromosomes). This characteristic is important in pollination. Plants of species with the same chromosome number can effectively pollinate each other, whereas crosses between species with different chromosome numbers rarely, if ever, set fruit.

In most of eastern Canada plants of the two common species, velvet-leaf and common lowbush, are found intermingled in lowbush blueberry fields. Plants within a given species differ greatly in vigor and productiveness; in color, shape, and size of leaves; in resistance to foliage disorders; and in earliness, flavor, size, color, firmness, and shape of fruit.

DEVELOPMENT OF THE PLANT

Most of the new shoots of mature plants develop from dormant buds on underground stems called rhizomes. The tips of growing shoots die in the early part or middle of the summer and the buds develop into either vegetative or flowering types. Whether a particular bud will be vegetative or flowering is determined the year the shoot arises. By late September most, though not all, flower buds can be distinguished from vegetative buds (Fig. 1) because they are usually about three times as large. The ratio of flower to vegetative buds is greater on new sprouts than on older twigs. The flower buds formed on new sprouts are also hardier and contain more flowers per bud.

Lowbush blueberry plants spread by rhizomes. The rhizomes give rise to additional roots and new crowns, which may develop to a size and shape similar to the parent crown. If separated from the parent plant, a piece of rhizome with well-developed roots can grow to be a separate plant. In moderately heavy sod, rhizomes grow an average of 5–8 cm per year. In areas with few competing plants, however, blueberry rhizomes have been found to grow as much as 38 cm in one season.

Typical lowbush blueberry flowers are shown in Fig. 2. The two essential organs for fruit development are the pistil, which receives the pollen on its sticky tip, and the stamens, which produce the pollen grains (Fig. 3).

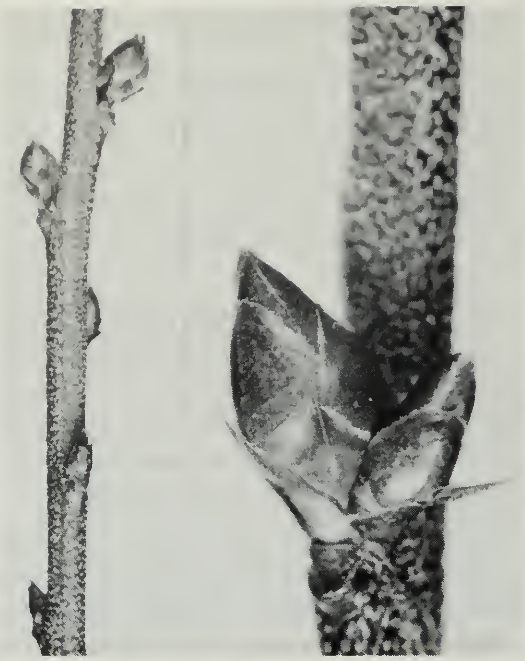


Fig. 1 *Left*, flower buds (at top) and vegetative buds of the common lowbush blueberry. *Right*, an extra flower bud, which sometimes develops on a vigorous shoot.

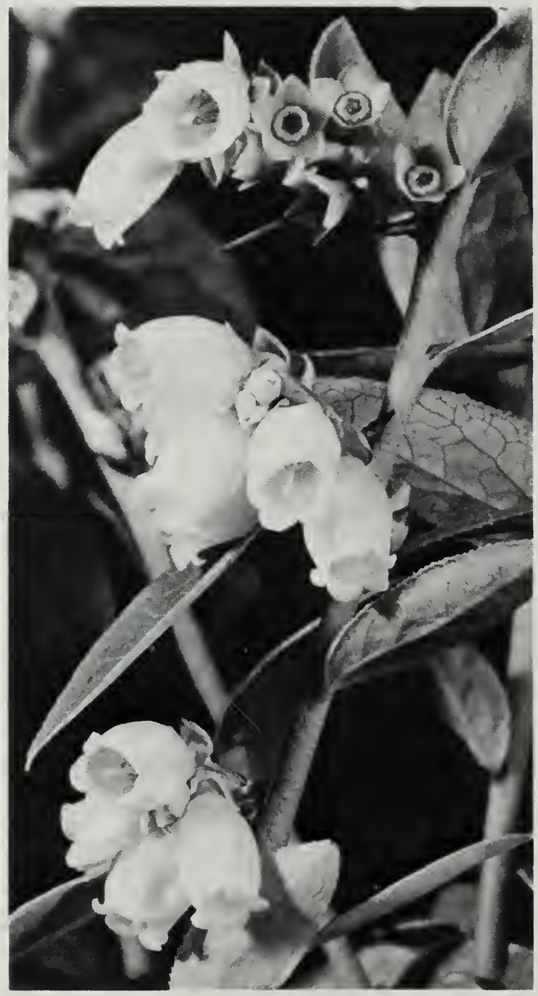


Fig. 2 Blossoms of the lowbush blueberry, about 5 mm long.

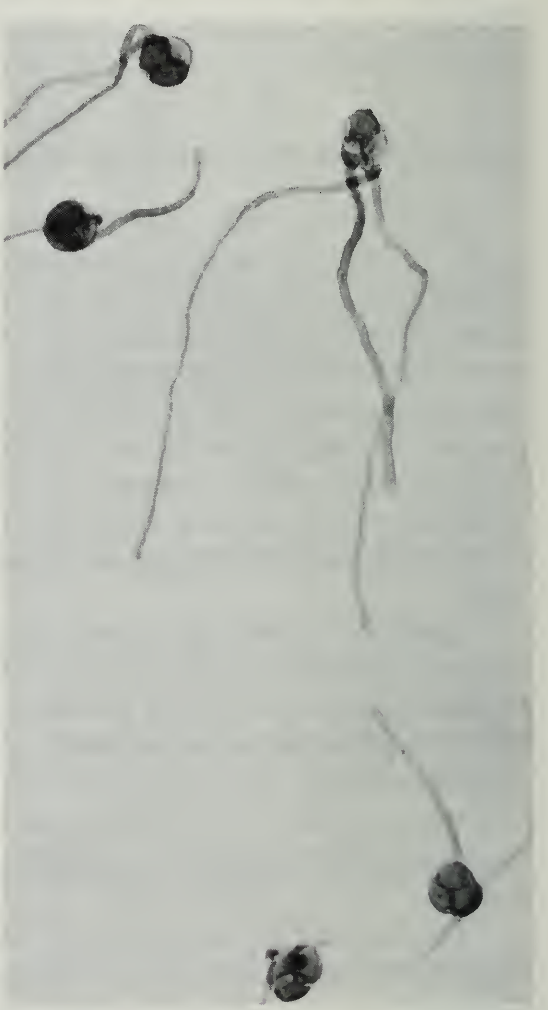


Fig. 3 Each germinating pollen grain may produce up to four germ tubes. These grow down the pistil into the ovary where fertilization occurs.

POLLINATION

The flowers need to be pollinated by insects, of which bumblebees, solitary bees, and introduced honeybees are the usual ones. Bumblebees and solitary bees work in colder weather than honeybees. In places where wild bees are scarce the introduction of colonies of honeybees usually ensures a higher fruit set. In many areas a honeybee population of two hives per hectare is considered necessary for adequate pollination. To benefit most from the use of bees, delay the placement of hives in the field until the middle third of the blooming period, because honeybees can cover a wide area in search of blossoms. For the first 2 or 3 days after release, honeybees work mainly within a few hundred metres of the hive, but they gradually extend their range to more than 1 km. Honeybees are particularly useful when rapid development of the flowers in warm weather shortens the pollinating season.

SOIL REQUIREMENTS

Lowbush blueberries occur throughout eastern Canada, especially on light, well-drained soils. The pH of these soils is generally in the range 4.0–5.5.

Although blueberry plants respond to applications of fertilizer, especially to nitrogen from ammonium (NH_4^+) compounds, competing plants also respond vigorously. Under our present cultural methods, fertilizers are helpful only on soils of extremely low fertility, so it is well to make a test application. Apply a fertilizer to a small plot and evaluate its effects before applying it to the entire field. Under moderate fertility, fertilizers stimulate competing plants more than the blueberries. This growth makes picking more difficult and often reduces the fruit yield. Under extremely infertile conditions applications of fertilizer may stimulate grass growth with no reduction in crop yield. This condition is especially true in Newfoundland, where the additional grass is needed to carry a fire when burn pruning.

DEVELOPING BLUEBERRY FIELDS

Abandoned farmland has the greatest potential for blueberry production because the land has been previously leveled and cleared of rocks. It is then easier to burn, dust, and harvest. Through cultivation, woody shrubs have largely been removed and the weed problem consists more of keeping out weeds than of controlling existing plants. However, many productive fields, especially in New Brunswick, have been developed from former woodlands. In either case, the procedure for developing the blueberry field is essentially the same.

First, cut and remove any trees on the area. Haul the brush to a barren area, such as a rock pile, for burning. Do not burn brush in the field because the intense heat from such a fire will destroy underlying blueberry plants. Burn brush only when the fire hazard is low. Mow hardwood saplings with a rotary mower (Fig. 4) before burning.

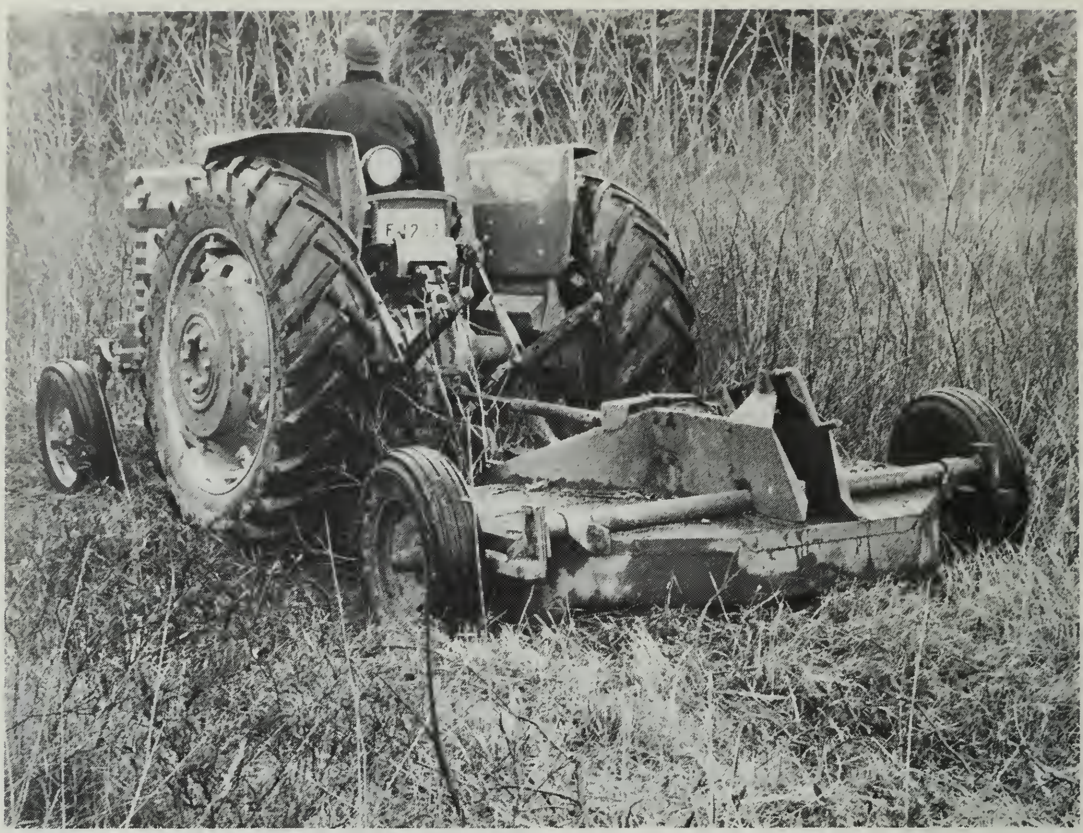


Fig. 4 A rotary mower cutting brush in preparation for burning the field.

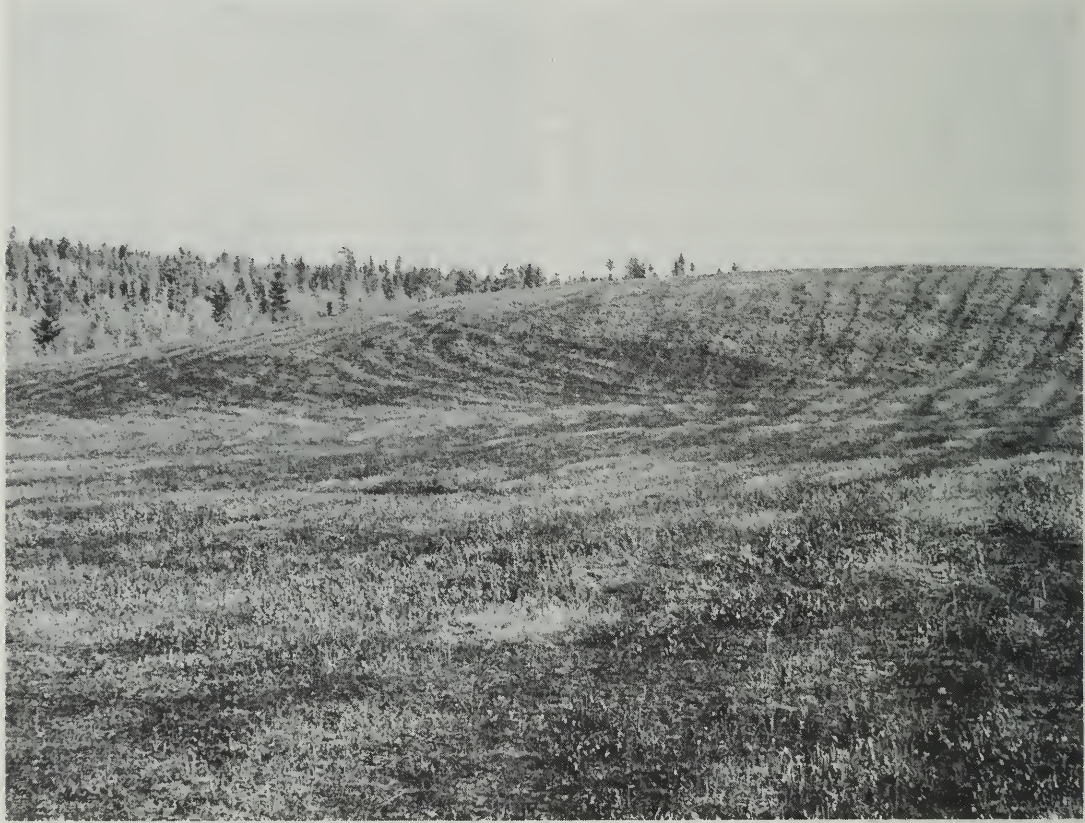


Fig. 5 Field after burn pruning.

PRUNING

Burning and flail mowing are pruning procedures. Old, highly branched bushes have few flower buds and must be replaced by single shoots, which are more productive. Prune the entire area (Fig. 5) without leaving any "islands" because old plants provide refuge for insects and fungi.

Burn or mow in late fall or early spring. Pruning induces the growth of new sprouts, many of which will have flower buds. Delay fall pruning until 4–5 weeks after spraying if 2,4-D or dicamba has been used to control woody weeds, or prune early in the spring to reduce injury to the plants. No fruit will develop during the next growing or sprout season. The fruit will develop during the second season, and, if the plants are not pruned after this harvest, a small crop will develop during the third season.

Divide your blueberry land into two sections and prune one section each year. For burn pruning, build a fire guard by plowing three or four furrows around the edge of the area intended for burning. If it is not possible to plow or bulldoze a strip, burn a swath with an oil or gas burner when the bushes are wet. Have some other workers on hand to take care of any emergency.

BURNING

Straw, oil, and propane gas are the types of fuel commonly used.

Straw

The average cost of straw burning is $200–$250 per hectare. This fuel is recommended for growers who have a cheap supply of marsh hay or straw. Scatter 1500–2500 kg of straw over each hectare (Fig. 6). Spread straw late in the fall after harvest and burn as early in the spring as possible. Burning in late spring damages the shoot growth, and the fire hazard is greater than in early spring.

Oil

Oil burning (Fig. 7) costs $175–$250 per hectare and is the best way to prune large areas of blueberries, except where fields are extremely rough. Set the burner so that 375–475 L of stove or furnace oil are needed to burn one hectare. Have the fire just hot enough to kill the twigs.

Propane gas

Propane gas is used only minimally for pruning (Fig. 8). Because it is slower than oil burning, it is recommended only for growers with small fields or areas. Adjust the burners so that 225–300 kg of propane gas are needed to burn one hectare.

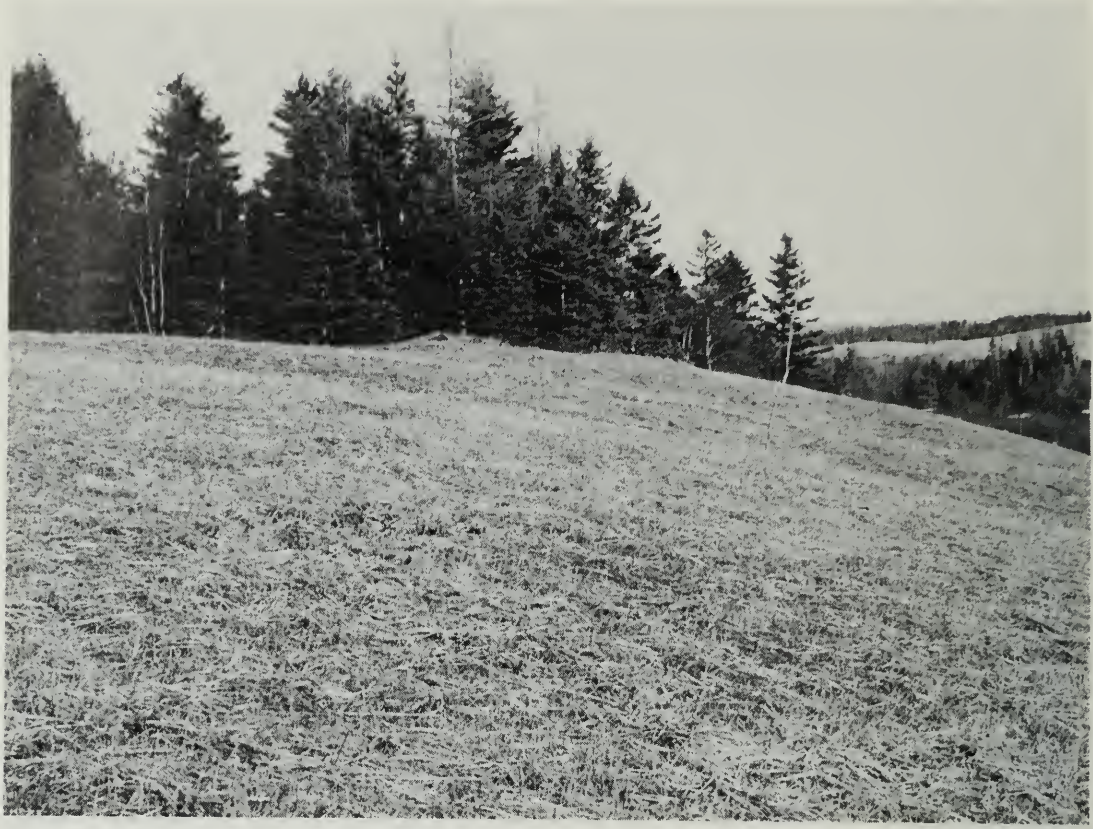


Fig. 6 A properly strawed field.

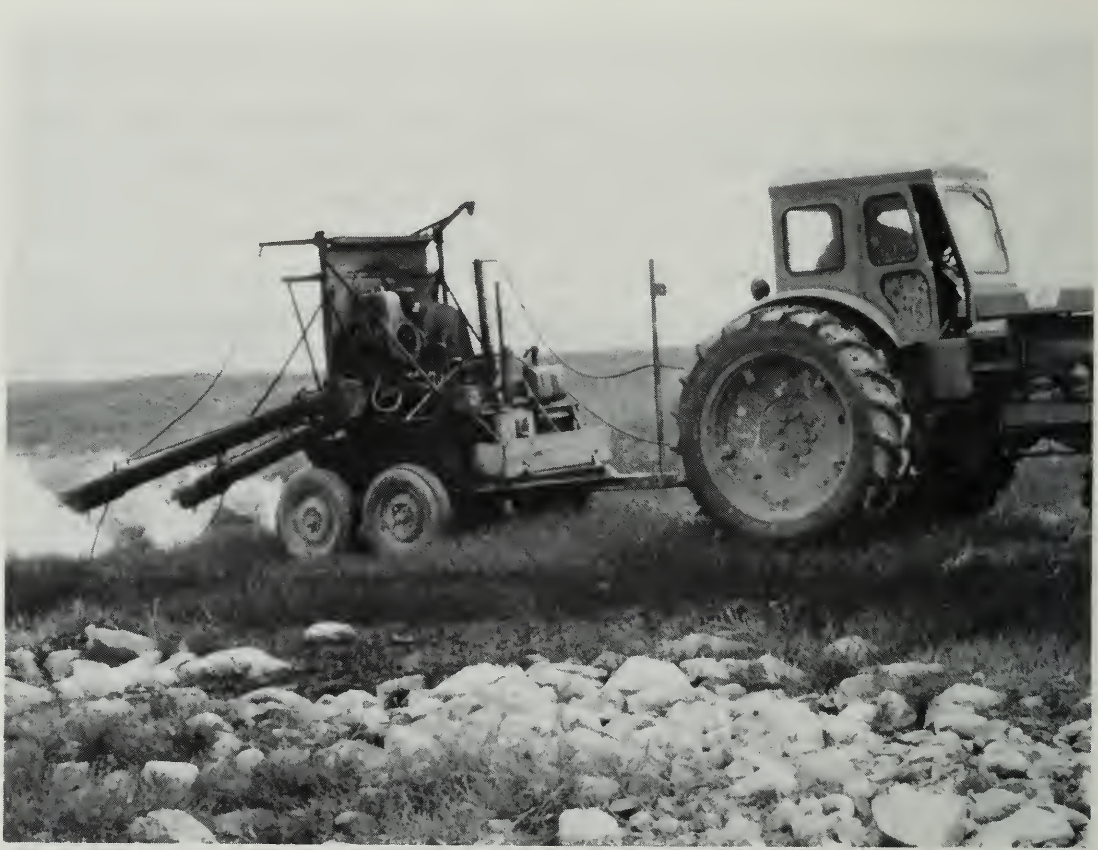


Fig. 7 An oil burner.

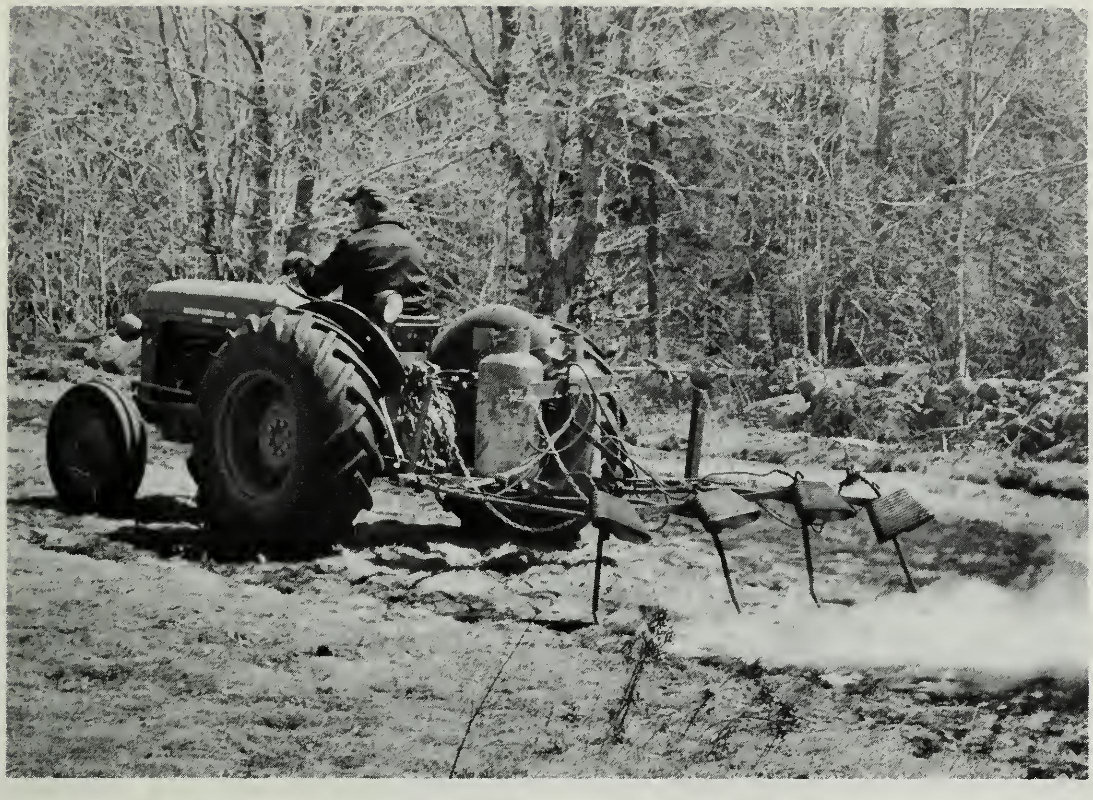


Fig. 8 A propane gas burner.

Mowing

The use of flail mowers (Fig. 9) for pruning has become increasingly popular as growers attempt to lower production costs. Mowing is less expensive than burning and is most effective on level ground. Repeated mowing in successive production cycles may lead to more problems with insects and disease.

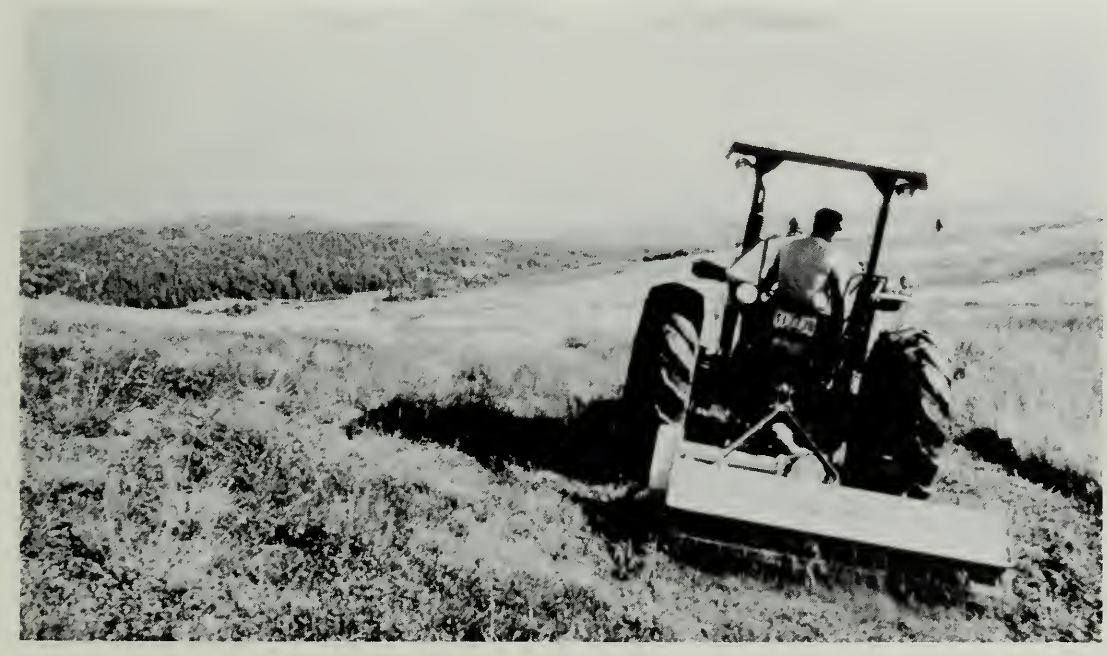


Fig. 9 A flail mower used for pruning.

PICKING

Harvest the field when 90% of the berries are blue to get the most attractive pack of fruit. Buyers will not accept green berries and foreign material because their removal is time-consuming and increases the cost of production. Delay harvesting as long as possible but not too long in a cool season, because berries touched with frost have little market value.

Divide each field with cord into lanes 2–3 m wide (Fig. 10) and assign a picker to each lane. Where possible, the pickers should have their backs to the sun. In this position they are better able to see the fruit.

Lowbush blueberries are usually harvested with a hand rake. Pickers run the rake through the bushes in a forward and upward motion, catching the berries on the rake teeth. The berries collect in the bottom of the rake. After every two or three strokes, twigs and grass are moved by passing the bottom of the rake over the side of a hand, and the berries are poured over the back of the rake into a pail or other container. At the end of the field the berries are weighed, cleaned, and emptied into shallow boxes (Fig. 11*A*,*B*,*C*) for trucking to a central plant (Fig. 12). Some growers transport harvested berries directly to a receiving shed where they are air-cleaned (Fig. 13) and then shipped to the central plant.

Recently, commercially successful mechanical harvesters (Fig. 14*A*,*B*) have been introduced and about 100 of these machines now operate in eastern Canada. Although their use is restricted to fields that are fairly smooth and weed-free, a harvester can pick up to 6.0 t of berries per day in good cropping conditions. In 1987, about 20% of the Nova Scotia crop was machine-harvested.

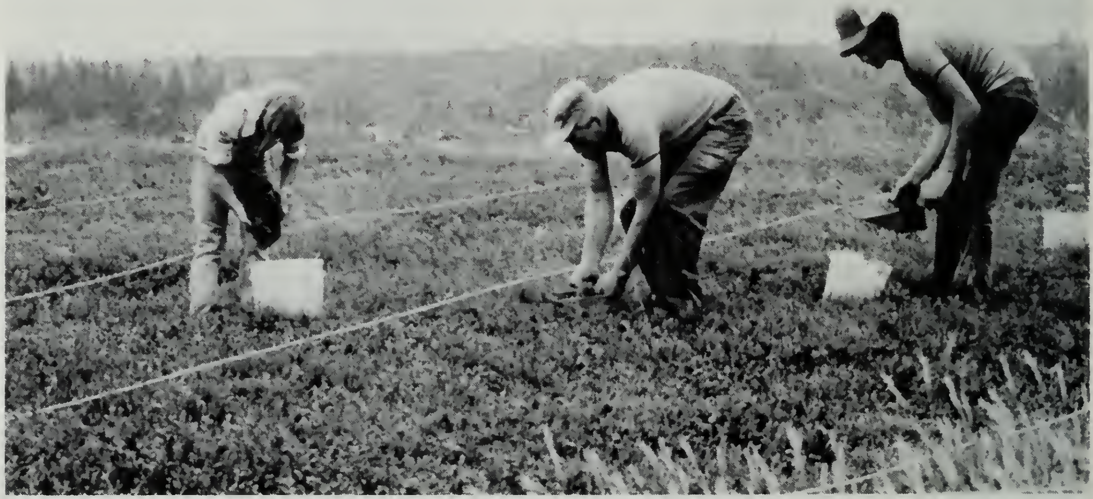


Fig. 10 Part of a blueberry field, showing cord separating the lanes for picking.

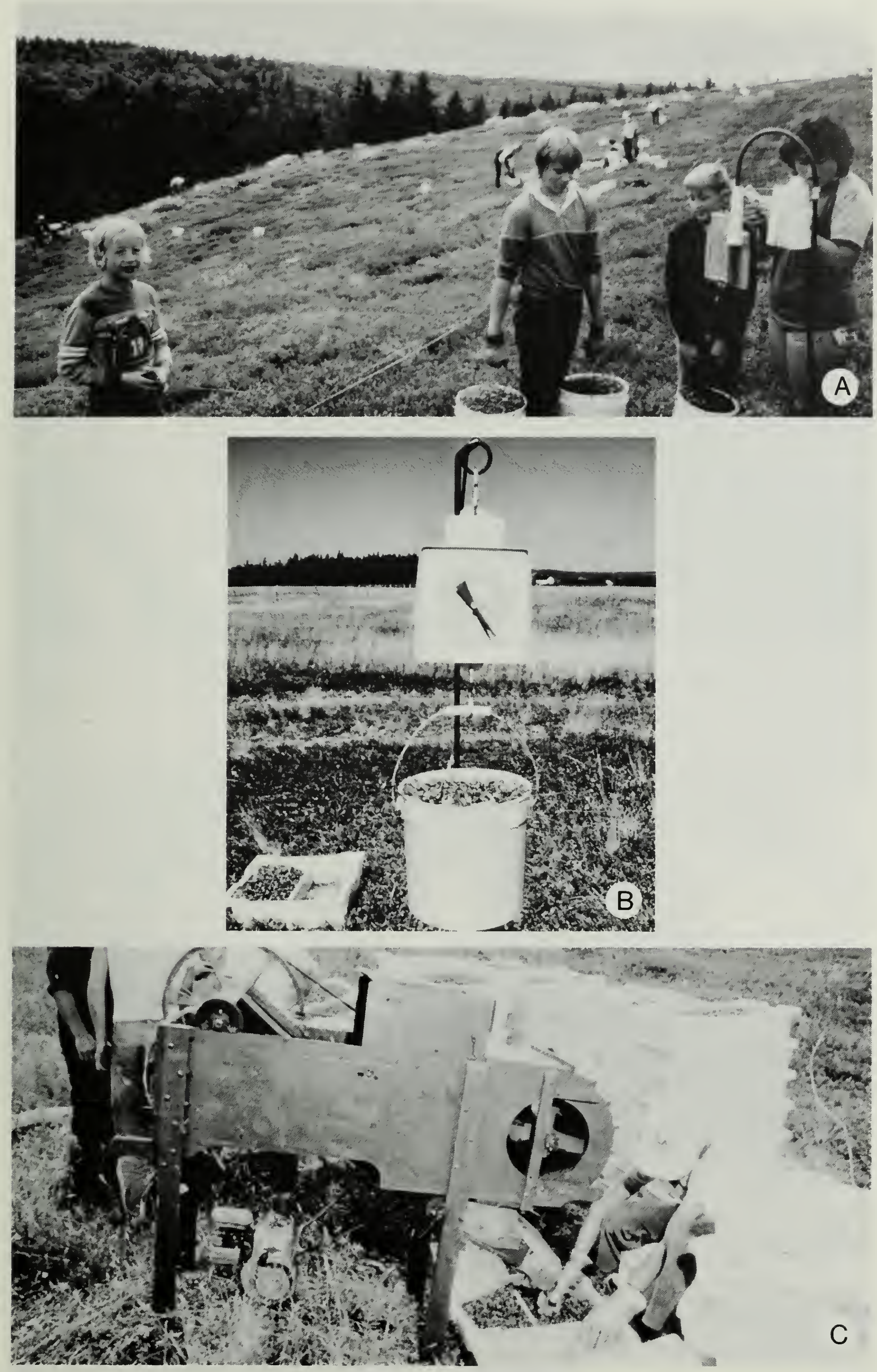


Fig. 11 Harvesting blueberries: (*A*) berries brought from the field in pails; (*B*) weighing berries; (*C*) field cleaning by winnowing and ready for shipping in plastic boxes.

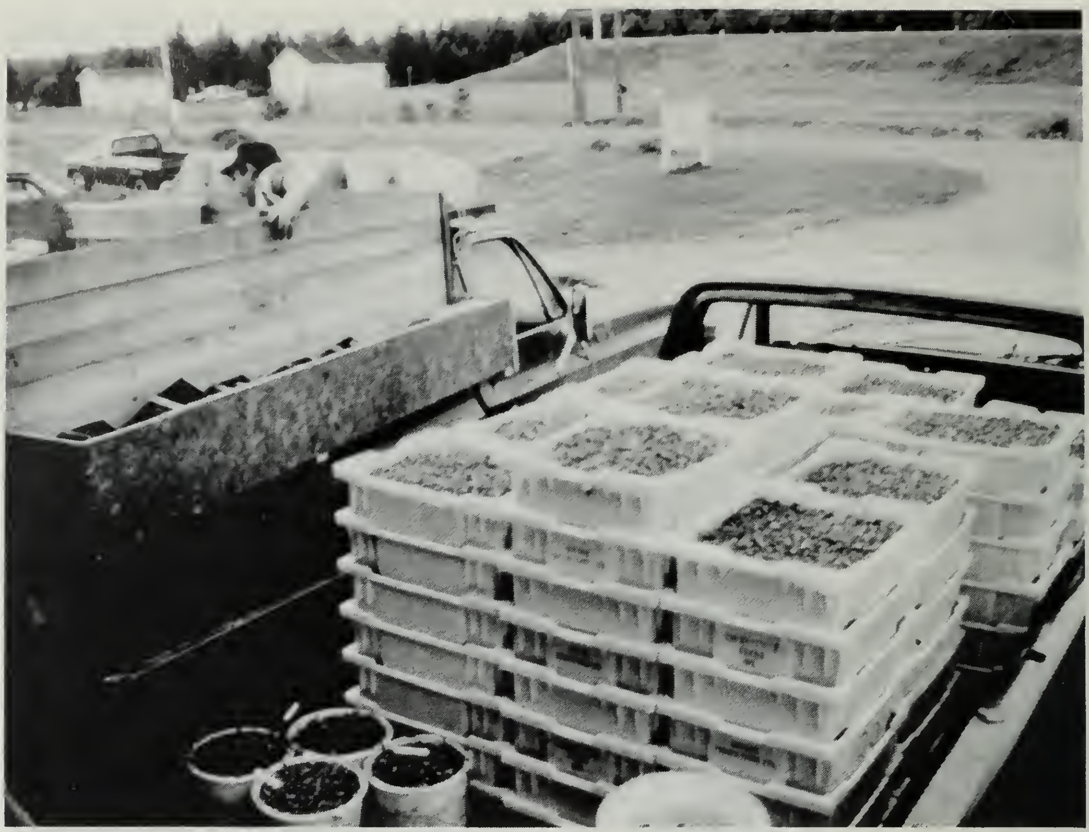


Fig. 12 Berries loaded for trucking to a central plant.

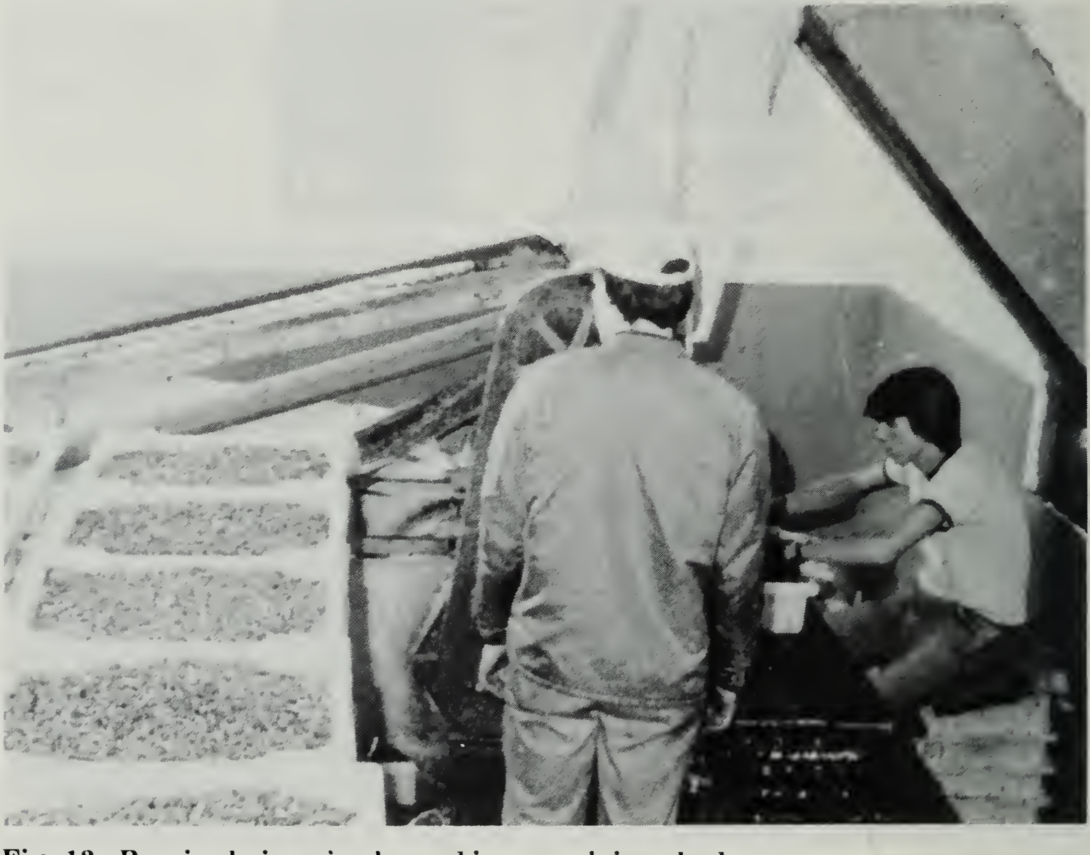


Fig. 13 Berries being air-cleaned in a receiving shed.

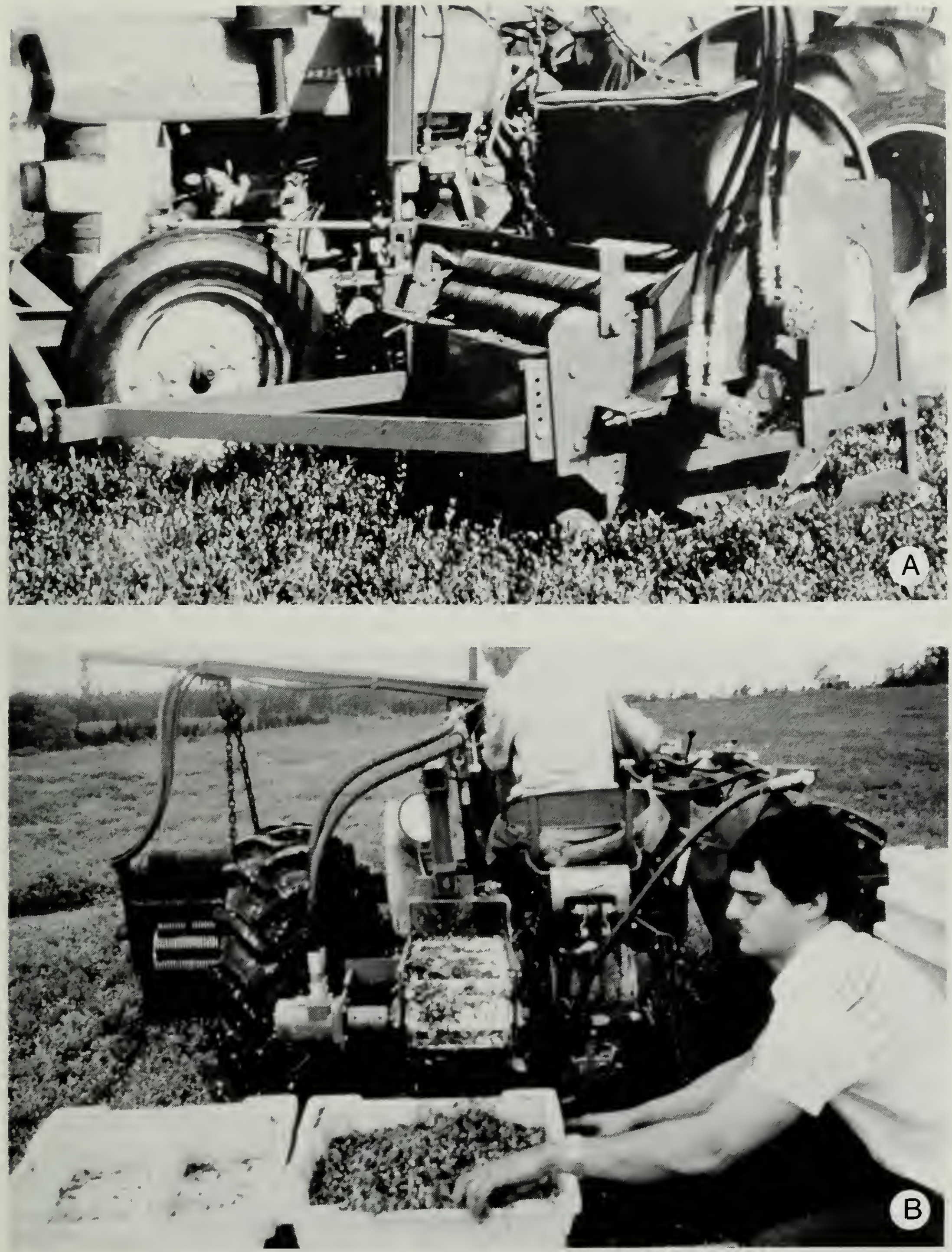
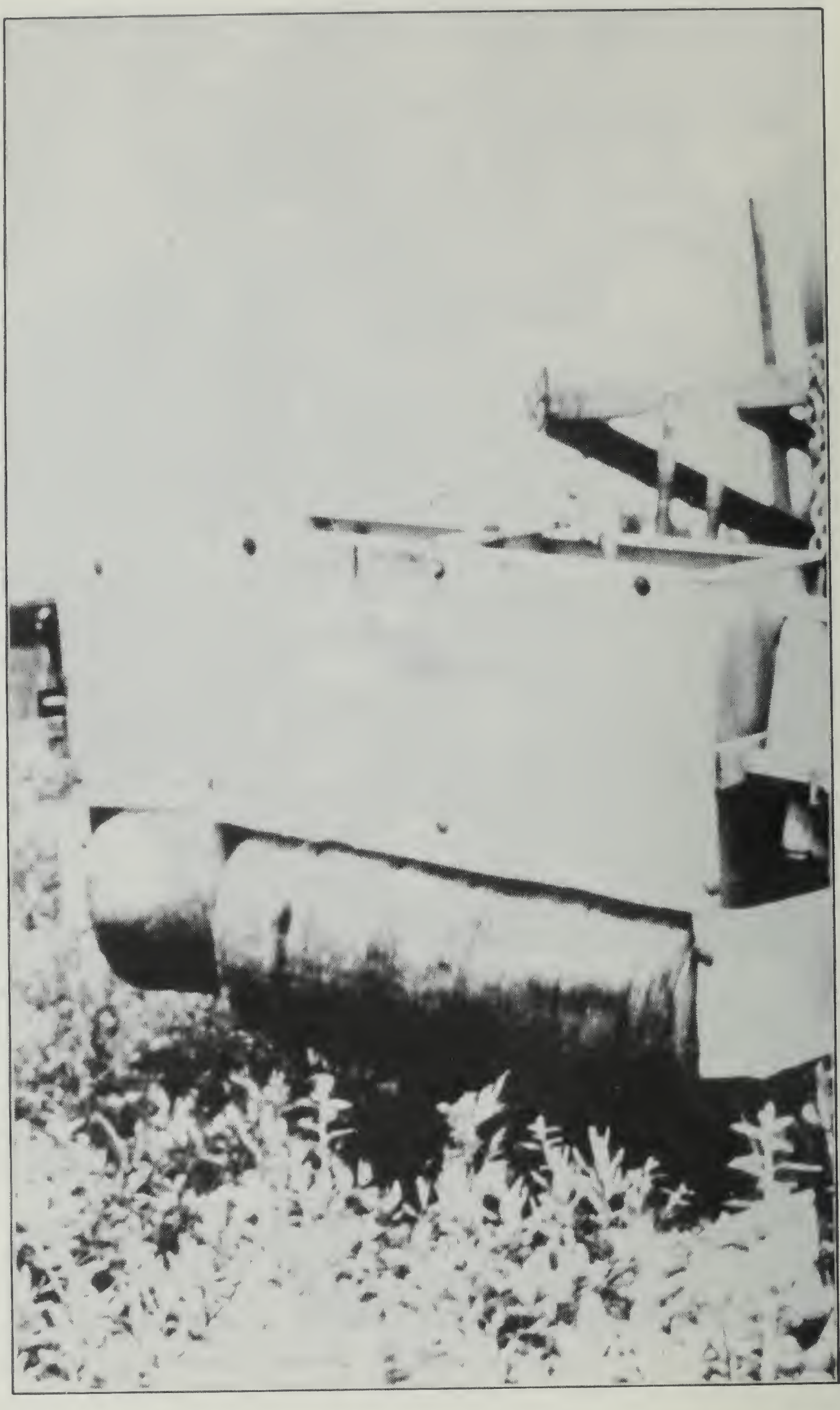


Fig. 14 A mechanical harvester: (*A*) side view showing rotating picking head; (*B*) rear view showing machine-cleaned fruit filling a plastic, two-compartment field container.



WEEDS

K.I.N. Jensen

WEED CONTROL

The weeds occurring in lowbush blueberries, like the crop itself, are species of the native flora that survive and are promoted by the 2-year crop cycle. Weeds constitute one of the major production problems in lowbush blueberry culture. Good weed control is necessary to maximize crop yield. It also allows the use of fertilizer and facilitates harvesting, especially with the newly developed mechanical harvesters. Until recently, weed control was restricted mainly to cutting and mowing and to wiping or spot treatments of phenoxy-type herbicides. These labor-intensive treatments often resulted in crop injury and, in many cases, failed to give satisfactory control of many weed species.

Recent increases in lowbush blueberry production have resulted, in part, from the industry widely adapting the use of certain selective soil-applied herbicides, particularly hexazinone. However, good, long-term weed control in lowbush blueberries will depend on developing flexible programs based on:

- use of soil-applied residual herbicides
- selective applications of growth-regulator herbicides to control escaping weeds
- use of mowing and cutting where applicable and the natural control obtained by a dense, competitive crop.

SELECTIVE, SOIL-APPLIED HERBICIDES

Burn pruning is unique to the culture of lowbush blueberries and the period after the burn, but prior to emergence of the new shoots, offers an opportunity to use soil-applied herbicides, which, if applied directly to the plants, would induce unacceptable crop injury. Two *s*-triazine herbicides, atrazine at 4.5–8.0 $kg \cdot ha^{-1}$ and hexazinone at 1.5–2.0 $kg \cdot ha^{-1}$, and the uracil terbacil at 1.5–2.0 $kg \cdot ha^{-1}$ are registered for this use. These herbicides are applied in spring following the burn but prior to blueberry emergence. Applications made at other times of the year are less effective in providing weed control and increasing yield. Terbacil and hexazinone may cause significant crop injury if applied to blueberry foliage. Providing good weed control during the pruning year has been shown to increase blueberry stem density and numbers of floral buds per stem. Yield increases exceeding 100% are not uncommon. Herbicides can also be used in conjunction with mowing.

Because it provides vastly superior weed control, hexazinone is the most important and widely used herbicide (Fig. 15). Although terbacil

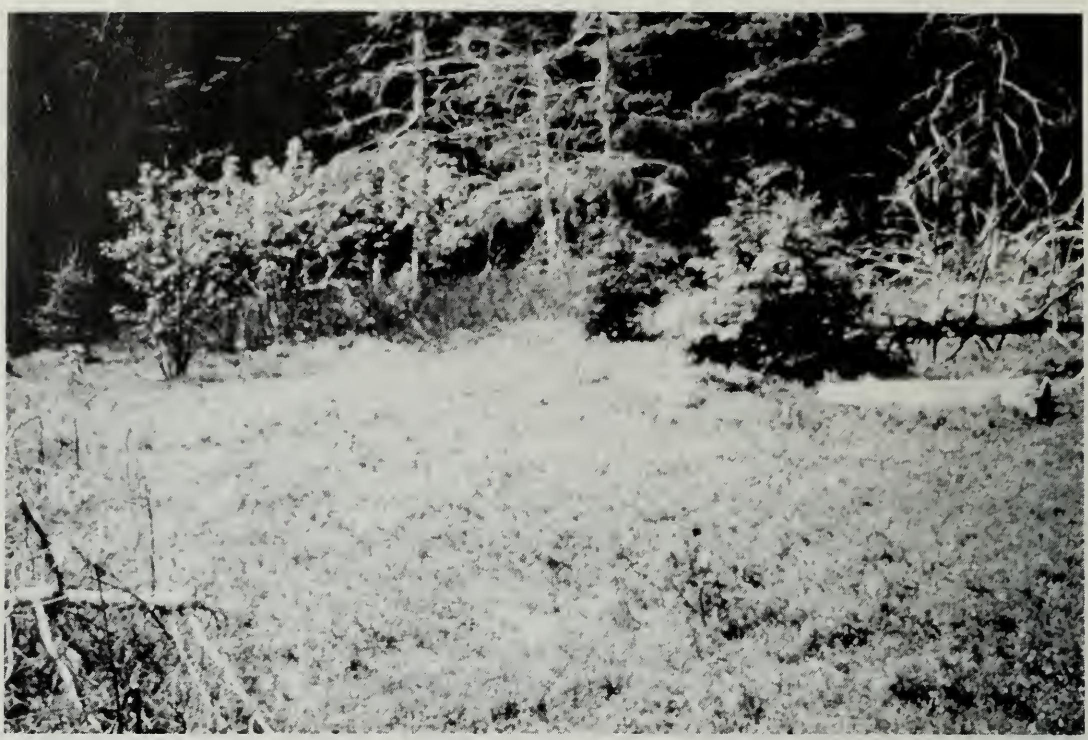


Fig. 15 Bringing new land into production with land clearing and hexazinone.

controls grasses and atrazine controls herbaceous broadleaved weeds, hexazinone controls a wide spectrum of important woody tree and shrub species in addition to grasses and broadleaved weeds at rates tolerated by blueberries. Some of these woody species include blackberries and raspberries, poplars, wild roses, sheep-laurel, broad-leaved meadowsweet, Labrador tea, and sweet-fern (Fig. 16). Although some blueberry clones may also be sensitive or injured by hexazinone and crop injury has been observed on poorly drained sites, crop tolerance is generally adequate. The failure of soil-applied herbicides to control adequately such species as bunchberry, black chokeberry, bayberry, tufted vetch, eastern bracken, and others is resulting in the growing importance of these species as weed problems in lowbush blueberry cultivation. Thus, follow-up treatments are of continuing importance to control these tolerant species.

NONSELECTIVE, GROWTH-REGULATOR HERBICIDES

If applied directly to the blueberry foliage, these herbicides are nonselective and can kill the crop. However, several novel and selective application techniques employing this type of herbicide have been used for many years in lowbush blueberry culture. First, water-soluble amine formulations of 2,4-D are employed as foliar sprays or wiping treatments; second, oil-soluble 2,4-D esters are applied in oils as basal bark or stump treatments; and third, dicamba is applied either alone or with 2,4-D as foliar treatments. Spot treatments of 2,4-D esters in diesel or No. 2 fuel oil to freshly cut stumps gives good

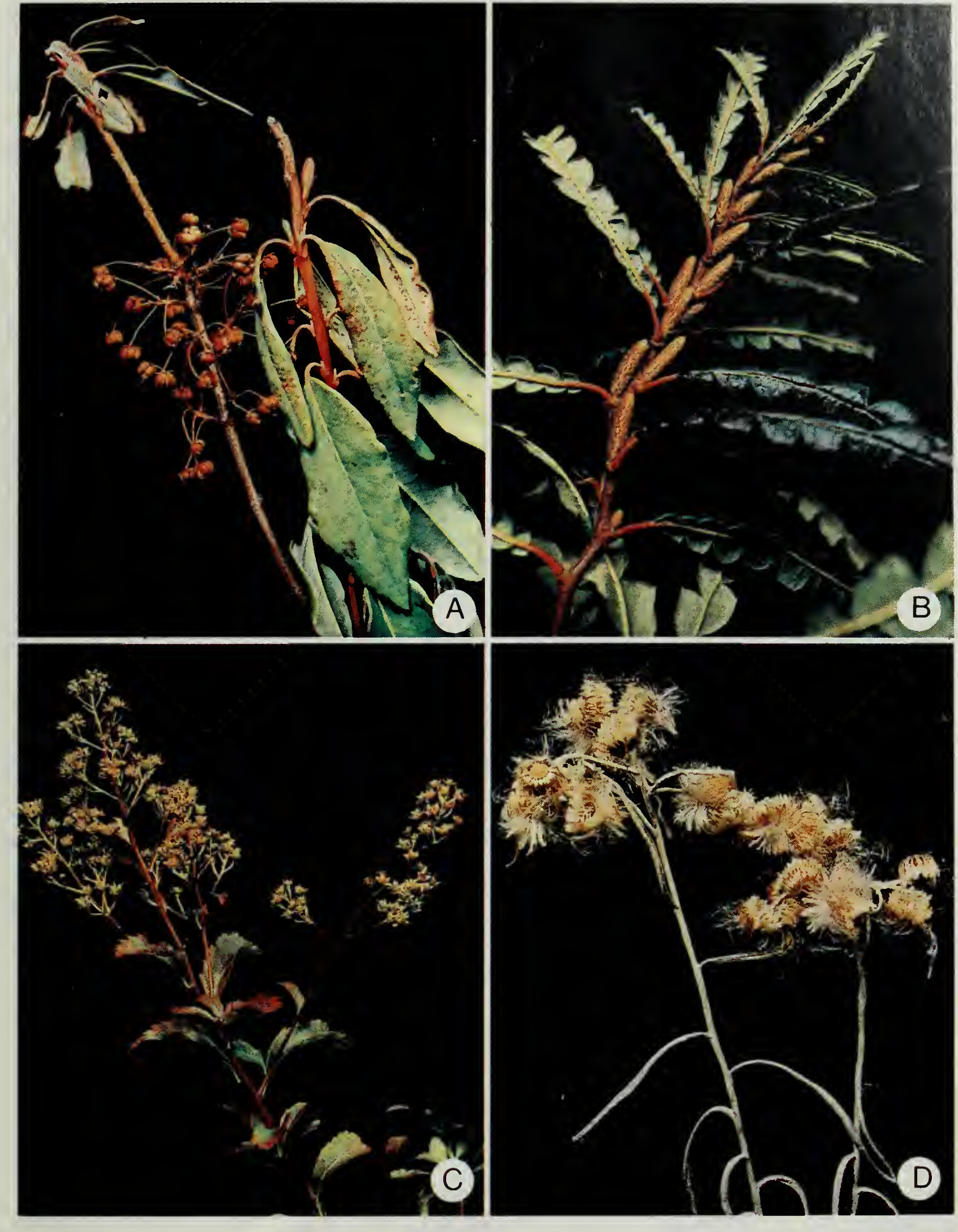


Fig. 16 Some troublesome weeds found in blueberry fields: (*A*) sheep-laurel; (*B*) sweet-fern; (*C*) broad-leaved meadowsweet; (*D*) pearly everlasting.

control of birches, willows, poplars, and alders. Either the use of nozzle shields on the handgun or applications made at times of the year when blueberry foliage is not present decreases injury to the crop. Spot treatments of aqueous mixtures of 2,4-D alone or in a 2:1 tankmix with dicamba are used for midsummer foliar applications to brush and small trees. Broadcast foliar applications of these herbicides against such sensitive weeds as sweet-fern or sheep-laurel can be made in heavy infestations where the weed canopy protects the blueberries from the spray. Invariably growers must accept some crop loss and injury from these treatments, but this loss can be reduced with careful application.

Several selective application techniques employing these herbicides have been developed. For example, herbicides can be applied in midsummer to vegetation taller than blueberries by means of mechanical roller–wiper applicators, which have been used in blueberry production for many years. In farm-made or commercial models (Fig. 17), the herbicide—generally a 2,4-D and dicamba mixture at 1.0 and 0.5 kg, respectively, in 200 L water—is sprayed onto an absorbant-covered drum, which rotates in a direction opposite to that of travel. Set above the height of the crop, these applicators selectively wipe taller vegetation. These types of roller applicators are now used to apply other herbicides selectively, principally glyphosate, in other crops as well. Several weed species that retain their foliage year-round, for example sheep-laurel or bearberry, can be treated selectively with 2,4-D and dicamba after the crop has been harvested and 90% of the blueberry leaves have fallen. Herbicides absorbed by the blueberries are apparently not translocated to the rhizomes and

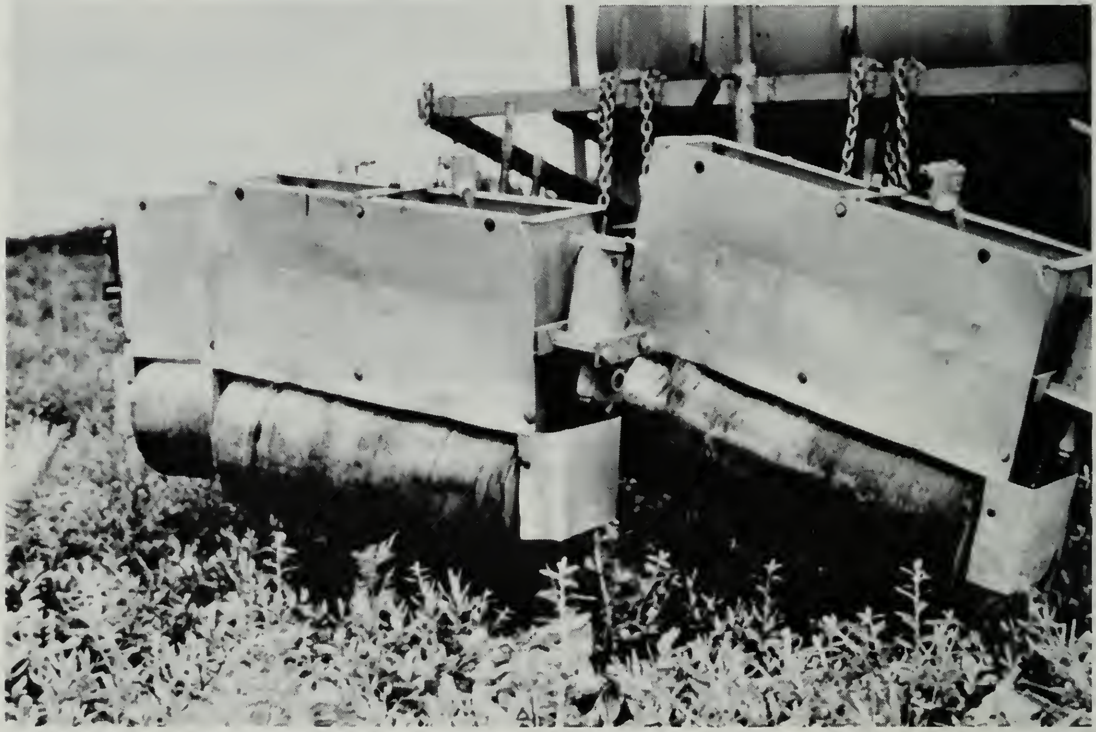


Fig. 17 A mechanical roller–wiper applicator for applying herbicides.

are destroyed when the blueberry topgrowth is subsequently burned. Harvested blueberries drop their leaves relatively early compared to such woody species as alders, sweet-fern, blackberries, bayberry, and others, permitting the selective application of growth regulator herbicides in October. Such foliar treatments would cause severe crop damage if applied earlier. It is especially recommended that following hexazinone application, programs employing these foliar or stump treatments be implemented while infestations of hexazinone-tolerant weeds are small and manageable.

MOWING, CUTTING, AND OTHER MEANS OF CONTROL

Because most perennial herbaceous and woody species can readily regenerate from basal buds near or below the soil surface or from buds on roots or rhizomes, cutting and mowing treatments give little or no long-term control of most species. Exceptions are the conifers (pine, spruce, and fir), which do not regenerate if cut below the lowest living branch. Some success in controlling eastern bracken has been obtained with several mowings per summer repeated over two or more years. Cutting followed by herbicide treatments to regenerating vegetation is used when bringing new or long-neglected fields into production.

Some highly productive fields remain surprisingly weed-free with little or no weed control. This observation suggests that a dense, highly competitive and productive crop will itself contribute significantly to weed control. Efforts to prevent infestation from areas bordering the fields and to encourage good blueberry growth should contribute to overall weed control and may, in time, reduce dependence on herbicides.

INSECTS

W.T.A. Neilson and L.M. Crozier

Blueberry Maggot (*Rhagoletis mendax* Curran)

The blueberry maggot is the most important insect pest of lowbush blueberry in the Maritime Provinces. Although common to most blueberry areas in Maine and the Maritimes, it is not a problem in Quebec and apparently does not occur in Newfoundland. This insect demands attention, not because of the crop losses due to larval feeding, but because the presence of maggots makes fresh, canned, or frozen fruit unacceptable for marketing. Shipments of fresh fruit from the Maritimes to Newfoundland and British Columbia are prohibited. Shipments to all other noninfested areas in Canada must be inspected and certified to be maggot-free.

The adult is a fly, slightly smaller than a house fly and is readily recognized by black bands across the wings and white lines on the abdomen (Fig. 18*A*). The adults emerge from late June to late August. Their numbers peak during the 2nd and 3rd weeks of July. Egg laying begins 7–10 days after emergence with peak numbers occurring during the 3rd and 4th weeks of July. The eggs are laid beneath the skin of the fruit, usually one per berry (Fig. 18*B*). A few days later, the eggs hatch into maggots (larvae) (Fig. 18*C*), which feed within the berry for 2–3 weeks, then drop to the ground and burrow into the soil to form puparia that house overwintering pupae. Most pupae develop and emerge into adults in the following year. However, a few remain and do not develop into adults until the 2nd or 3rd year.

The adults prefer areas with a plentiful supply of berries that are sheltered from prevailing winds by woods, weeds, hollows, rocky outcrops, or rock walls. As a result, their distribution and that of infested fruit is often uneven, unless populations are at extremely high levels. When the adults are prevalent, infested berries can be found in all areas where berries are numerous (Fig. 18*D*). Yellow, rectangular, sticky traps are very attractive to the adults and when displayed in the preferred sites will detect the adults at very low population levels. Their use monitors adult activity to determine the need and timing for control treatments.

The blueberry maggot has no important natural enemies. Cultural practices of weed suppression and burning the fields every 2nd or 3rd year helps to reduce maggot populations, but in most areas insecticides are necessary.

Blueberry leaftier (*Croesia curvalana* (Kearfott))

The blueberry leaftier (Fig. 19*A*) has recently become an important pest of lowbush blueberry in the Atlantic Provinces, particularly in the Avalon Peninsula of Newfoundland and in some fields in New Brunswick and Nova Scotia. Leaftiers are most abundant on wild, abandoned, or poorly managed blueberry land. Outbreaks, however, occur occasionally on improved blueberry fields and in areas where the plants are mowed for pruning purposes. Crop damage can be extensive because of the invasion of larvae into the flower buds in early spring. Insecticide treatments may be required to prevent crop losses. Leaftier numbers are generally at low levels in fields that are burned every 2 years.

The blueberry leaftier overwinters in the egg stage as a partly developed larva in the egg case. The larvae (Fig. 19*B*) emerge in late April to mid May. Newly emerged larvae burrow into unexpanded flower buds (Fig. 19*C*) in late April and later feed on expanding leaf buds (Figure 19*D*). Late-instar larvae move about freely and leaves are often webbed and rolled together. The larvae pupate during June either in leaves spun together or hanging freely by the cremaster attached to any part of the plants. The adult moths emerge during July and reach peak numbers in late July. Males emerge first followed by females several days later. Eggs are laid singly on dead leaf litter around the base of blueberry plants in late July and early August. Initially, they are white, but within 3 days they turn brown and enter a prolonged diapause for 5–6 months. A few eggs hatch in the fall, but their larvae cease feeding and die in 3–4 days.

Other species of leaftiers and leafrollers inhabit lowbush blueberry fields and cause damage similar to that of the blueberry leaftier. However, they are not as prevalent and have not caused any substantial crop losses.

Blueberry spanworm (*Itame argillacearia* Packard)

The blueberry spanworm has recently become an important pest of lowbush blueberry in Maine. It is also present in the Maritime Provinces and occasionally causes extensive damage to leaf and flower buds, blossoms, and vegetative shoots (Fig. 20*A*). In severe outbreaks, current crop yields are reduced and extensively damaged areas have the appearance of burned areas with only twigs and stems remaining.

The spanworm overwinters in the egg stage. The larvae begin feeding in early May, at first on developing leaf and flower buds and subsequently on the leaves and tender stems. They feed mainly at night and may be difficult to find during the day. They can be recognized readily by their looping habit of walking and distinctive colors. Young larvae are about 3 mm long and light tan to gray with black markings. Mature larvae are about 20 mm long and yellowish orange with rows of black spots (Fig. 20*B*). The larvae feed on the plants until late June or early July and then pupate in the ground litter. The adult moths emerge in July and lay their eggs in the litter layer beneath the plants.

Spanworm has become more prevalent with the introduction of mowing as a pruning method.

Blueberry thrips (*Frankliniella vaccinii* Morgan and *Catinathrips kainos* O'Neill)

Two species of thrips have been identified from lowbush blueberry. They are similar in appearance and are more common in sprout fields. Injury is easily recognized by tightly curled, red leaves (Fig. 20*C*). In sprout fields the leaves are generally wrapped around the stem of the plant, whereas in crop fields lateral or terminal leaf rolls are formed. Infestations are usually spotty, but in some sprout fields, they become major pests and may reduce yields by more than 50% in the following crop year. Infected sprouts bear little, if any, fruit during the following crop year and control treatments should be applied during the sprout year to prevent crop losses.

The adults overwinter in the soil and emerge in late April and early May. Eggs are laid in the developing leaf tissue in late May and early June, and the white to yellowish immature stages (nymphs) (Fig. 20*D*) are present within the curled leaves until early August. Adults of a new generation appear during July and August and are present within the curled leaves or move out into the soil to overwinter. Adults of both species are yellowish gray or a golden color and about 2 mm in length.

Blueberry flea beetle (*Altica sylvia* Malloch)

The blueberry flea beetle is common in many lowbush blueberry fields in the Maritimes and occasionally causes severe foliar damage resulting in crop losses. It is more prevalent in crop than in sprout fields, but can cause extensive damage in sprout fields that are close to infested crop fields. It is seldom a problem in fields that are burned every 2 years.

The blueberry flea beetle overwinters in the egg stage. The eggs hatch into small black larvae (grubs) (Fig. 21*A*) in the spring when the blueberry plants begin to develop. The black larvae are conspicuous feeding on the foliage, usually on the outer edges but often gnawing holes in the centre of leaves. They feed on the leaves until late June, enter the ground to pupate, and emerge as adults in early July. The adult beetles (Fig. 21*B*) are shining coppery bronze in color, round-shaped, and less than 6 mm long. Like all flea beetles, their hind legs are adapted for leaping and they jump when disturbed. The adults feed on the leaves and the foliage becomes pitted with minute perforations when they are prevalent. Eggs are laid in late July and August and do not hatch until the following spring.

Information on their natural enemies is scarce and insecticide treatments may be necessary to prevent crop losses.

Blueberry leaf beetle (*Pyrrhalta vaccinii* (Fall))

The blueberry leaf beetle occasionally causes damage to blueberry plants, especially in newly developed or poorly managed fields. The adults and larvae feed on the lower leaf surfaces between the veins, which results in skeletonization. The upper surfaces eventually turn brown. Severe infestations in successive years can kill the plants.

The adults overwinter in the litter at the base of blueberry plants. They emerge in late April and begin feeding on expanded leaf buds. They mate and lay eggs in crevices on the stems in late May and June. The larvae are greenish yellow to light brown and are present in late June and July. They pupate in the soil and the next generation of adults appears in late July and August and feeds until hibernation in late fall. The adults are small beetles about 4 mm long and vary in color from a dull yellowish brown to reddish brown.

Blueberry case beetle (*Neochlamisus cribripennis* (LeConte))

The blueberry case beetle is present in most blueberry areas and occasionally causes serious damage to the stems of blueberry plants. Although it feeds on both leaves and stems, extensive girdling of the stems kills these shoots and results in a crop loss (Fig. 21*C*). Although new growth arises from underground rhizomes after the field is burned, repeated feeding and girdling causes permanent damage. When prevalent, insecticides are necessary to prevent crop losses.

The blueberry case beetle overwinters as an adult and emerges in late April and early May. Eggs are laid singly in about mid June in a dark brown or blackish bell-shaped case of excreta attached to a leaf or stem by a short stalk. The larva hatches within the case and breaks it off from the stalk. It moves about with its abdomen curved upward within the case (Fig. 21*D*). The larva feeds mainly on the leaves but also to some extent on the fruit and stems. The case is gradually enlarged by the addition of excreta and at the time of pupation is about 5 mm long and resembles the burned head of a wooden match. The larva pupates within the case, which is sealed over and attached to the main stem or a branch of the blueberry plant. The adult emerges in August or early September and feeds on the bark of blueberry shoots until November. On many shoots only one or two areas of bark on the bottom 5 cm is chewed off, but other twigs may have a dozen or more chewed areas.

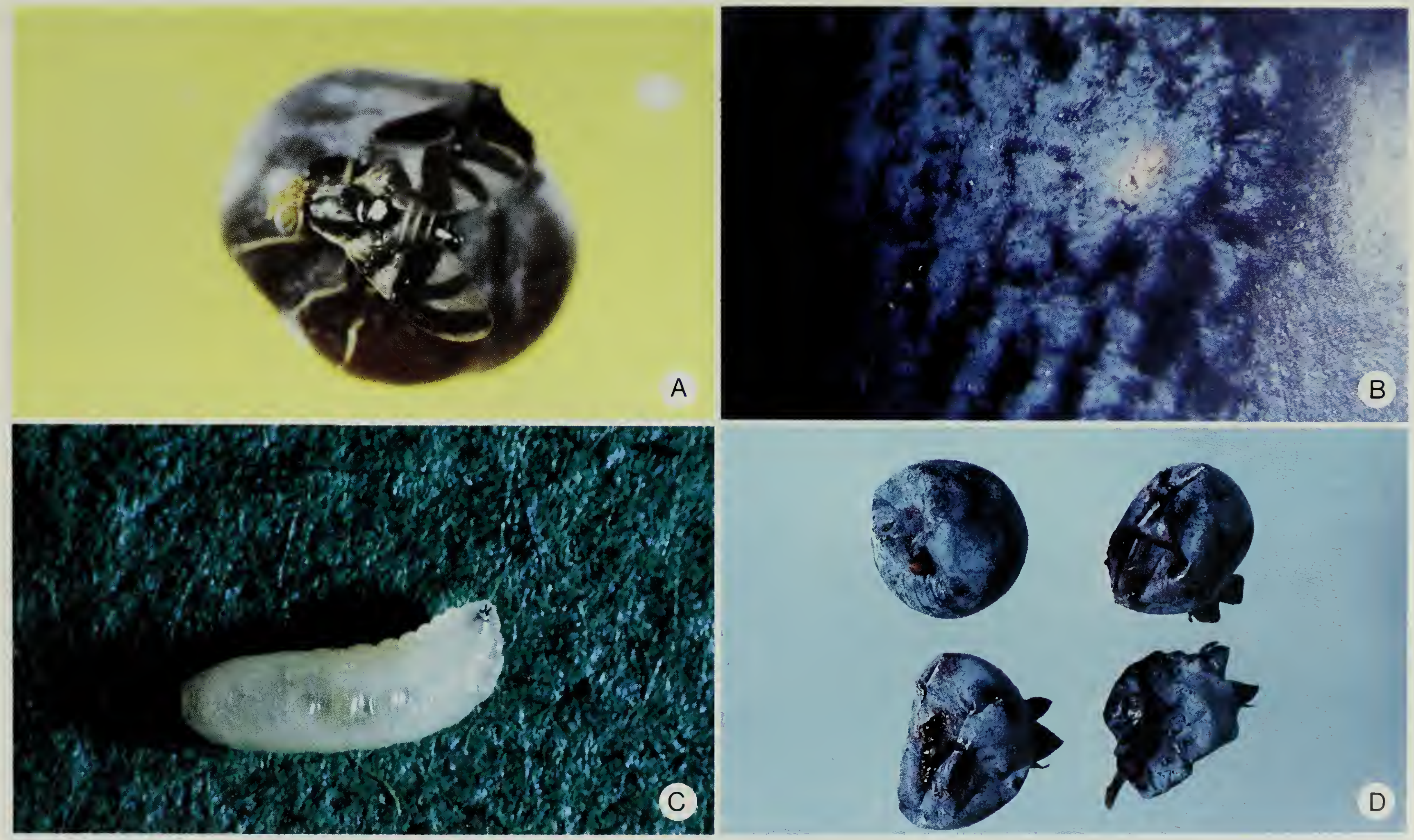


Fig. 18 Blueberry maggot: (*A*) adult; (*B*) oviposition 'sting'; (*C*) larva; (*D*) infected berries.

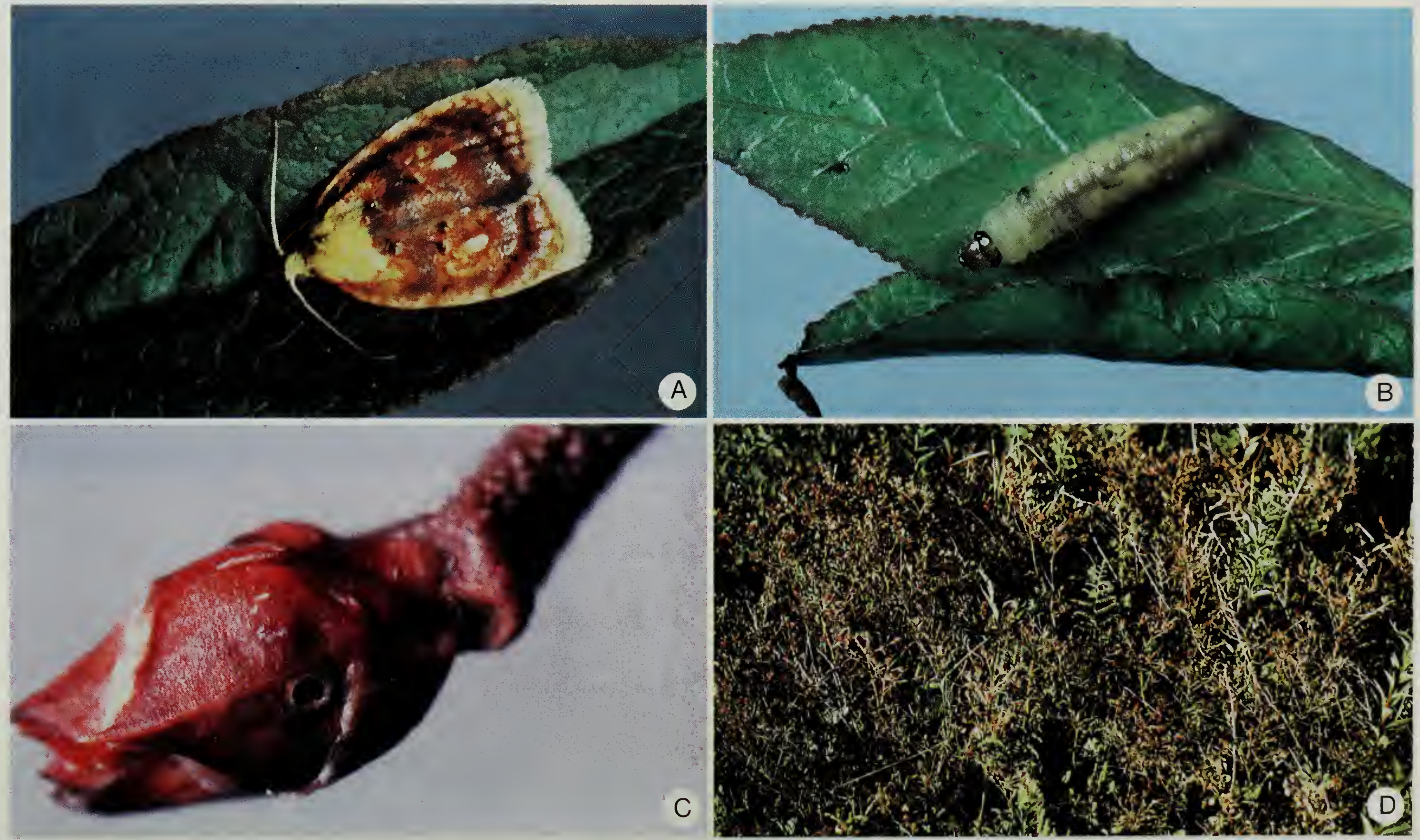


Fig. 19 Blueberry leaftier: (*A*) adult; (*B*) larva; (*C*) entrance hole in bud; (*D*) injury.

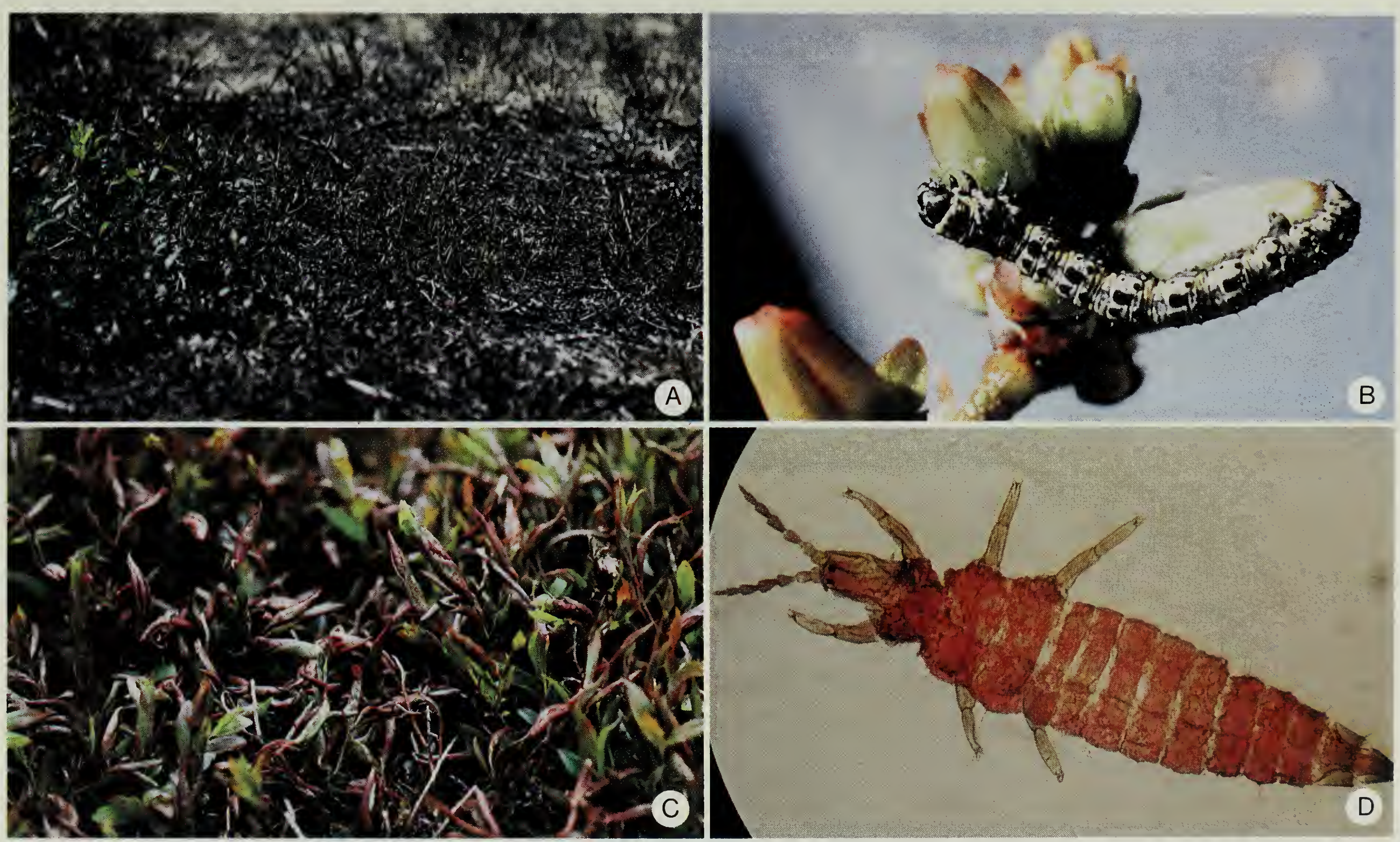


Fig. 20 Blueberry spanworm: (*A*) injury; (*B*) larva; and Blueberry thrips: (*C*) injury; (*D*) larva.

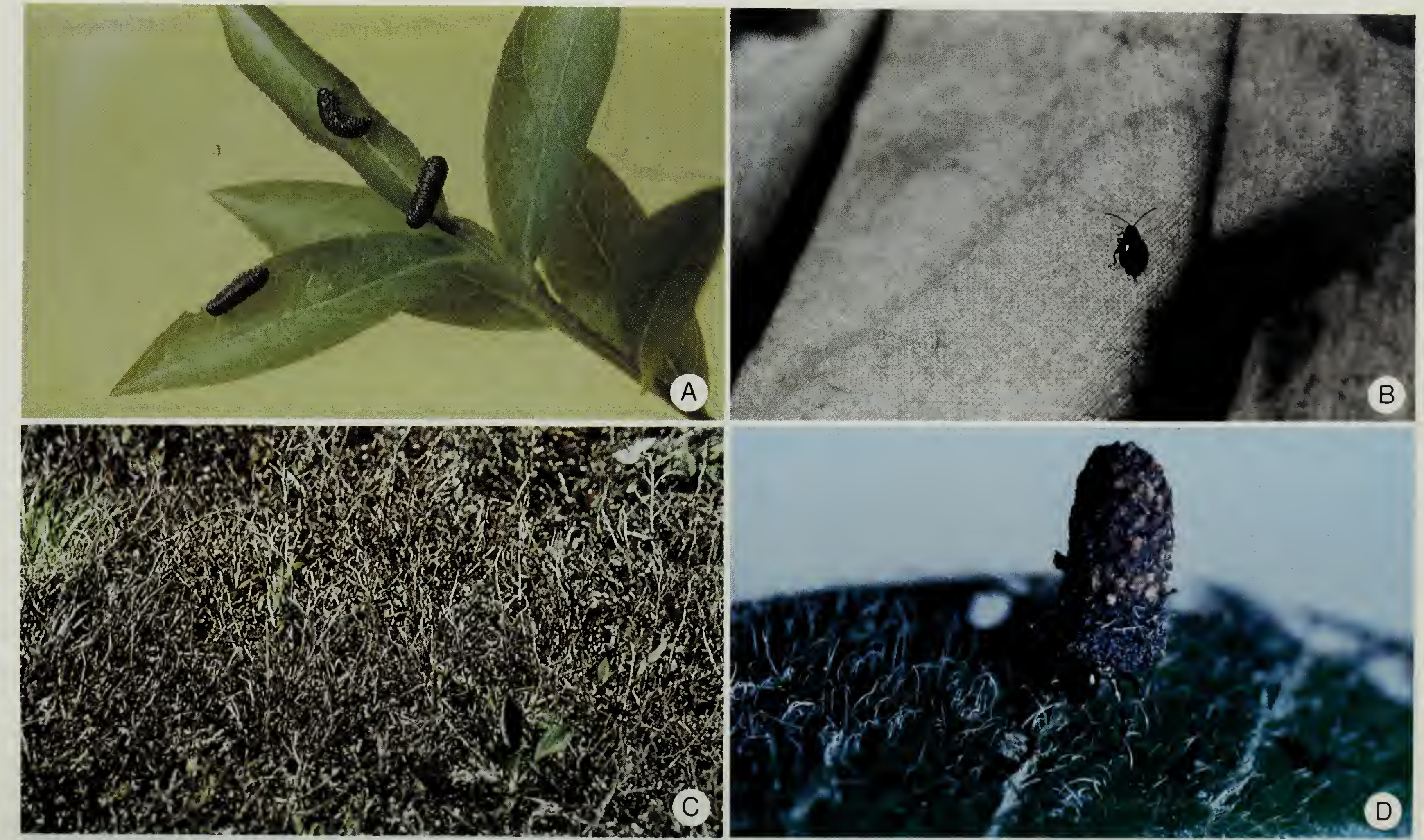


Fig. 21 Blueberry flea beetle: (*A*) larva; (*B*) adult; and Blueberry case beetle: (*C*) injury; (*D*) larva.

Black army cutworm (*Actebia fennica* (Tauscher))

Several species of climbing cutworms feed on blueberry foliage, but only the black army cutworm has caused extensive crop losses. In most years, the black army cutworm and other species are present in low numbers, but periodically widespread outbreaks occur to defoliate hundreds of hectares with substantial crop losses.

Cutworms overwinter in the soil or surface debris as small caterpillars (larvae) and, in late April, begin feeding on developing (expanding) flower buds. At this time, they feed mostly on terminal buds, eating out the interior after entering through a small hole that they have made in the side of the bud. As the buds grow, the contrast between injured and normal buds increases and infested areas become more conspicuous. The foliage of blueberry and other plants can be completely removed during heavy outbreaks and severely infested areas look as if they had been swept by fire. Cutworms usually feed at night and rest on the surface debris during the day. However, during heavy outbreaks and the rapid depletion of food supplies, they develop a marching habit and feed during both day and night, resulting in the complete defoliation of numerous fields.

The larvae of the black army cutworm are velvety black during the early instars with a white stripe along the sides. When fully grown (about 4 cm long), they are brownish black on top and grayish beneath. They feed from late April to early June, pupate within the litter layer on the ground, and emerge as adult moths during the latter part of July. The eggs are laid in late July and August and hatch in late September and early October. The larvae feed for a short period and then hibernate until the following spring.

Chainspotted geometer (*Cingilia catenaria* (Drury))

The chainspotted geometer is an occasional pest of blueberries but is seldom destructive, except during outbreaks when it may completely destroy the foliage and fruit. It also attacks many other plants such as sweet-fern, Canadian rhododendron, and hardhack, which are common on blueberry lands.

The larvae (caterpillars, measuring worms, inchworms) are yellowish in color with prominent black spots along the sides, and 4–5 cm long when fully grown. They move with a typical looping motion and feed from early June until late August. The larvae pupate in the litter layer in August and the adult moths are present during September and October. The moths may be distinguished by their smoky white, almost transparent wings, which are marked on their outer edges with faint lines and with several distinct black spots. The eggs, which are laid on the foliage of blueberry and other plants, overwinter on the fallen leaves.

Whitemarked tussock moth (*Orgyia leucostigma* (J.E. Smith))

The whitemarked tussock moths primarily attack broadleaf trees and bushes, but when they are prevalent will also attack evergreen trees and almost every green crop. They feed voraciously on blueberry and cause extensive damage. Fortunately, their outbreaks last only 1 or 2 years because the species is highly susceptible to disease and other natural control factors. However, during an outbreak, insecticide treatments may be required to prevent defoliation and subsequent crop losses.

The whitemarked tussock moth overwinters in the egg stage. The eggs hatch in late June or early July. The larvae (caterpillars) are yellow and black and are easily recognized by their unusual and interesting markings. They have long, black tufts of hair projecting out and forward from each side of the head and another tuft at the rear end and four tufts of short, grayish white hairs running along the back. The head is red and there are two bright red spots on the back. The larvae feed on the foliage, giving it a skeletonized appearance, until they attain a maximum length of about 4 cm. In August, they spin a loose cocoon and pupate on the host plants or sometimes in the crevices of nearby buildings. Grayish moths emerge after 2 weeks. The females are wingless and lay their eggs in masses on or near the cocoon, covering them with a frothy substance.

Redstriped fireworm (*Aroga trialbamaculella* (Chambers))

The redstriped fireworm is a minor pest of lowbush blueberry but occasionally causes severe damage in some fields. It is generally more plentiful in sprout fields, but it also attacks crop fields and can reduce yields by webbing of the fruit. Webbing presents difficulties in raking the crop and may also affect the size of berries.

The larvae fasten two or more leaves together with a silky web and skeletonize them from within the enclosure. In contrast to injury by thrips, the terminal leaves are held together with little curling. Injured plants are apparent by mid August and persist until late fall. When removed from the foliage, the larvae are easily recognized by their reddish brown color and rapid wiggling when disturbed.

Other blueberry insects

The following species of insects may cause damage to blueberries but in general they are only of minor importance and seldom require insecticide treatments.

The blueberry tip midge (*Contarinia vaccinii* Felt) causes a rolling of the terminal leaves of infested plants. The injury caused by the midge is similar to that of blueberry thrips, but the reddening of the foliage is less noticeable. The tip midge is usually found on the velvet-leaf blueberry, whereas thrips prefer the common lowbush blueberry. If one or more small maggots are found on injured foliage, there is little doubt that tip midges have caused the injury. Occasionally, both midges and thrips may inhabit the same leaf roll.

Grasshopper nymphs and adults (*Melanoplus* spp. and *Camnula pellucida* (Scudder)) have been observed feeding on blueberries. The extent of their feeding varies from year to year depending upon their prevalence. They feed on foliage and berries; their damage to fruit is often detected as a calloused scar.

The small leaf chafer (*Serica tristis* LeConte) sometimes appears in large numbers in blueberry fields during bloom and occasionally damages blossoms. Their appearance during bloom is cause for concern as it is most difficult to apply control treatments at this time.

Sawflies are fairly abundant in blueberry fields in some years, but their feeding does not seriously affect the crop. Of 19 species of sawflies that have been collected in blueberry fields by sweeping, only 3 species (*Neopareophora litura* (Klug), *Pristiphora idiota* (Norton), and *Pristiphora* sp.) feed on blueberry plants. *N. litura* is commonly found in most areas, whereas the others are scarce. Its larvae are usually green, but occasionally pink specimens are found. They are present both in the daytime and at night and feed on the outer edges of the leaves during May and early June. When fully grown (9–11 mm long), the larvae drop to the ground and hibernate within cocoons, which they spin within the litter layer. The adults emerge in the following spring and lay their eggs within leaf buds. Sawflies are more abundant in mowed fields than in burnt fields.

Stem galls are found occasionally on a few plants in blueberry fields. However, populations of insects (*Hemadas nubilipennis* (Ashmead)) that cause stem galls are usually at low levels and are not considered important.

DISEASE AND DAMAGE

P.D. Hildebrand and N.L. Nickerson

The lowbush blueberry is not susceptible to many widespread or destructive diseases, possibly because it is a native plant growing in its natural habitat. Many diseases are controlled or the level of infection is reduced by the cultural practice of burning stands every 2nd year. Burning destroys infected plant debris from which new infections could arise. Flail mowing does not destroy plant debris and therefore may result in increased levels of diseases. Control measures for any specific disease are usually applied only in areas where disease outbreaks occur or in fields that have a history of a particularly troublesome disease. Blueberry growers should be familiar with the common diseases.

COMMON DISEASES

Monilinia blight (*Monilinia vaccinii-corymbosi* (Reade) Honey)

Monilinia blight is an important fungal disease that attacks the leaves, blossoms, and fruit. The life cycle of the fungus is closely associated with the development of the blueberry. The blueberry is susceptible to infection during bud break. At this time, primary spores or ascospores are produced by the fungus and released from cup-shaped fruiting bodies originating from mummy berries produced in previous years. The ascospores infect young green tissues of vegetative and flower buds. Disease symptoms become evident about 10–20 days after primary infection has occurred and appear as water-soaked or dark brown areas along the midrib and veins of leaves, which soon wilt (Fig. 22*A*). Infected blossom clusters become dark purple-brown in color and shrivel, but they remain attached to the plant. Secondary spores or conidia are then produced as a gray growth on the midrib of infected leaves and at the base of infected blossoms. The conidia are produced as blossoms begin to open and are dispersed by wind and pollinating insects. The conidia infect the open blossoms where the fungus colonizes the young berry. The fungus continues to grow within the developing berry, which remains symptomless until almost mature at which time the fungus causes the berry to shrivel, harden, and turn salmon in color (Fig. 22*B*). This fungal mass or mummy berry drops to the ground where it overwinters. The remaining skin of the berry becomes silver in color and is sloughed off exposing the hard black fungal mass. In the spring, the mummy berries produce cup-shaped fruiting bodies or apothecia (Fig. 22*C*) from which ascospores are released, which in turn infect young blueberry tissues to complete the cycle.

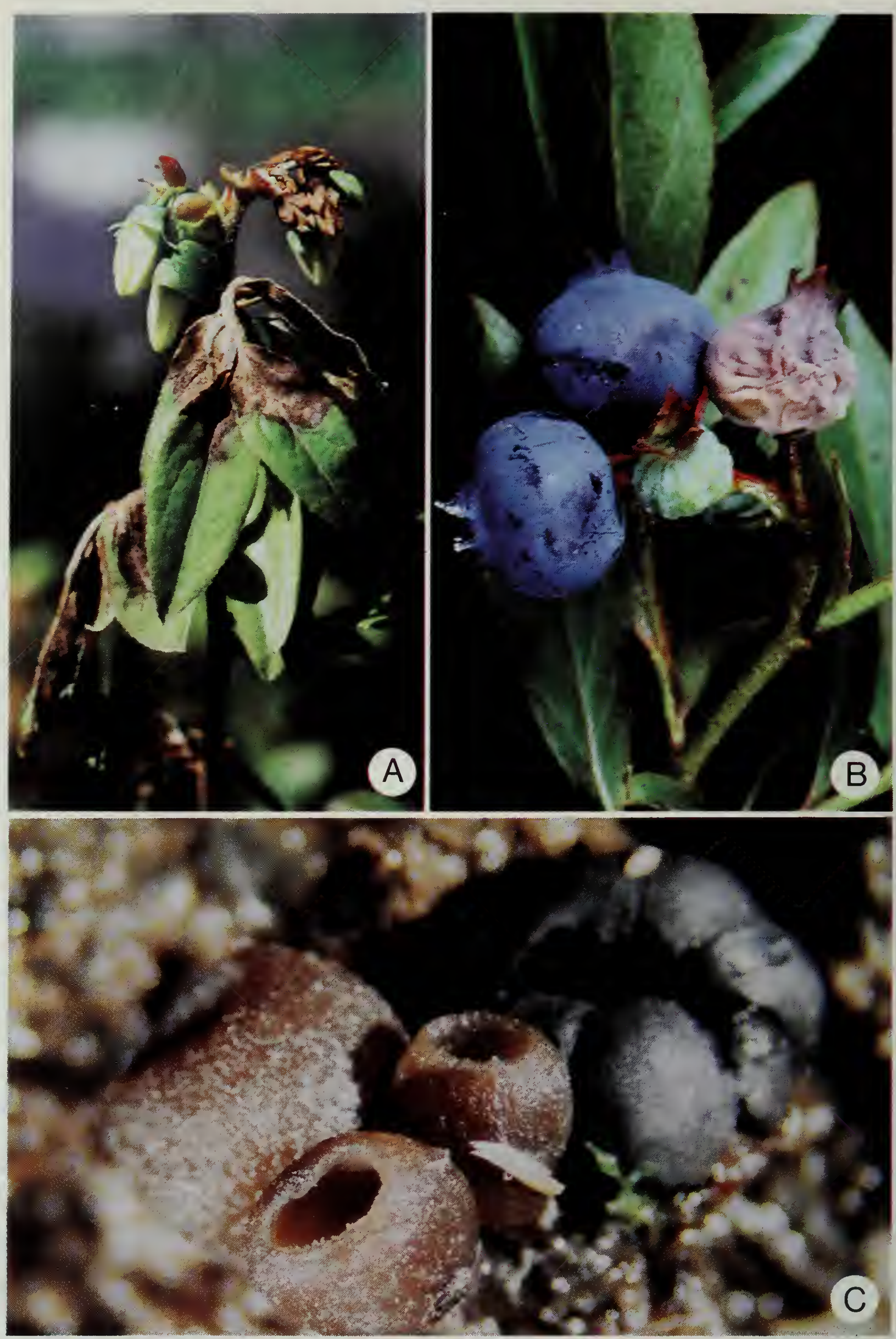


Fig. 22 (*A*) Leaves infected by monilinia blight. (*B*) Blueberry fruit infected by monilinia blight. (*C*) Monilinia blight fruiting bodies or apothecia produced on a mummy berry.

Monilinia blight is more serious in wet weather and in fields that are poorly drained. If rainfall is below average there may be inadequate soil moisture for apothecia to develop. If the weather is unusually dry following production of apothecia, there may be inadequate moisture for ascospores to infect young tissues so plants escape with little disease. Light frosts during bud break greatly increase the susceptibility of tissues to ascospore infections.

Fungicides are available for the control of monilinia blight. Fungicide spray programs are aimed at controlling ascospore infections during early development of blueberry tissues. Fungicide applications should begin when green tissues emerge from developing leaf and flower buds. A second application should be made about 7–10 days later. Good control of ascospore infections disrupts the life cycle of the fungus and greatly reduces production of conidia and subsequent formation of mummy berries.

The practice of burning lowbush blueberries every other year helps to control blight by destroying the mummy berries. Flail mowing does not destroy the mummy berries and therefore may result in increased levels of disease.

Botrytis blight (*Botrytis cinerea* Pers.)

Botrytis blight is a fungal disease that also attacks the leaves, blossoms, and fruit. It can be as destructive as monilinia blight and symptoms may be similar. Leaves infected by *Botrytis* turn light brown and become covered with a gray mold (Fig. 23). Spores produced by the mold attack the blossoms causing them to turn brown and cling to stems (Fig. 24). Young green fruit may be infected directly by spores or by contacting infected blossoms. Infected fruit shrivel and become dark brown. The fungus continues to produce its spores throughout the growing season on plant debris where it eventually overwinters.

Botrytis blight is favored by wet weather during the bloom period. Fungicides are available for control of this disease and should be applied beginning at mid bloom. A second application should be made at late bloom. Check your local spray guide for fungicide recommendations.

Red leaf disease (*Exobasidium vaccinii* Wor.)

Red leaf is a systemic disease of blueberries caused by the fungus *Exobasidium*. In fruiting fields, infected plants are easily recognized in June and July by the bright red color of their leaves (Fig. 25). The lower surface of the infected leaves becomes covered with a white, felt-like, spore-bearing layer of the fungus, which distinguishes diseased plants from those showing natural bronzing. By midsummer

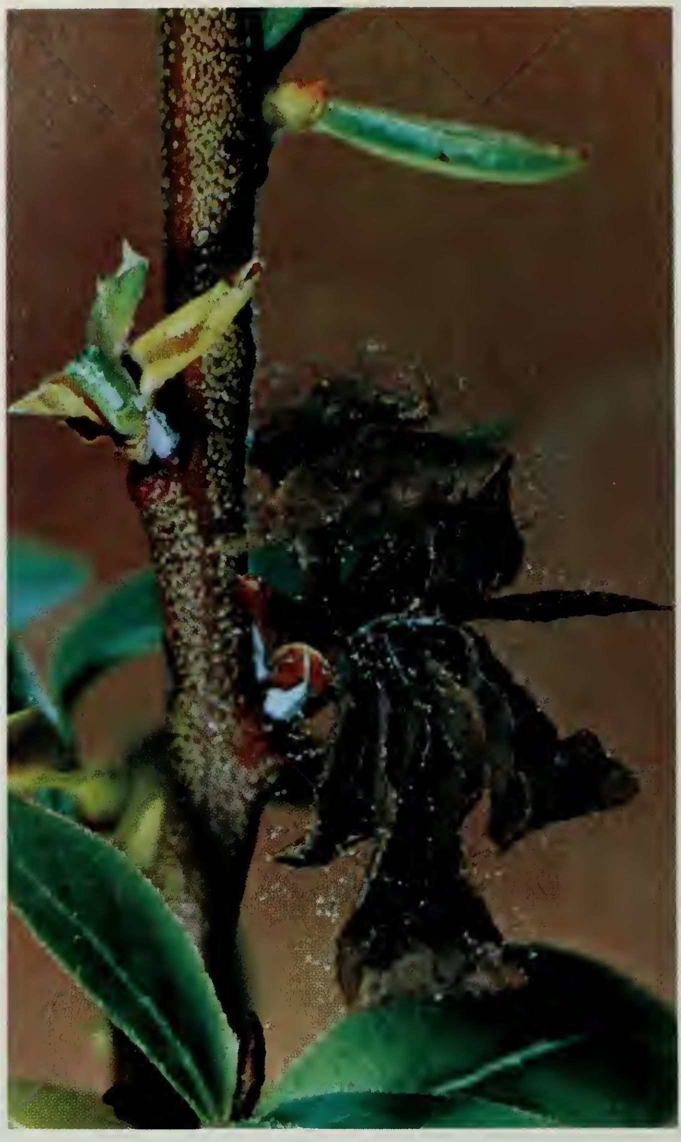


Fig. 23 Leaves infected by botrytis blight.

the infected leaves drop and the disease is inconspicuous for the rest of the season. However, symptoms reappear on the same plants each spring because the fungus overwinters in the stems and rhizomes. Symptoms are less conspicuous on first-year sprouts than on older stems. Infected plants usually fruit poorly and eventually die. The disease spreads by airborne spores and by mycelium through rhizomes of infected plants.

Red leaf disease often appears more severe than it actually is because the bright red patches of infected foliage are so conspicuous among the surrounding healthy green leaves. Recent surveys of native stands in the Maritime Provinces and Maine have shown that in most fields less than 2% of the shoots are infected, and disease levels above 5% are uncommon. Burn pruning probably destroys many new infections before they become established in the rhizome. Studies with greenhouse-grown plants have shown that some clones are resistant to infection. These and other factors appear to be keeping red leaf at a low level in most fields. Where red leaf is considered a problem, diseased plants should be eradicated by spot spraying with a recommended herbicide in the sprout year. Burning does not control the disease once the fungus has invaded the rhizome.

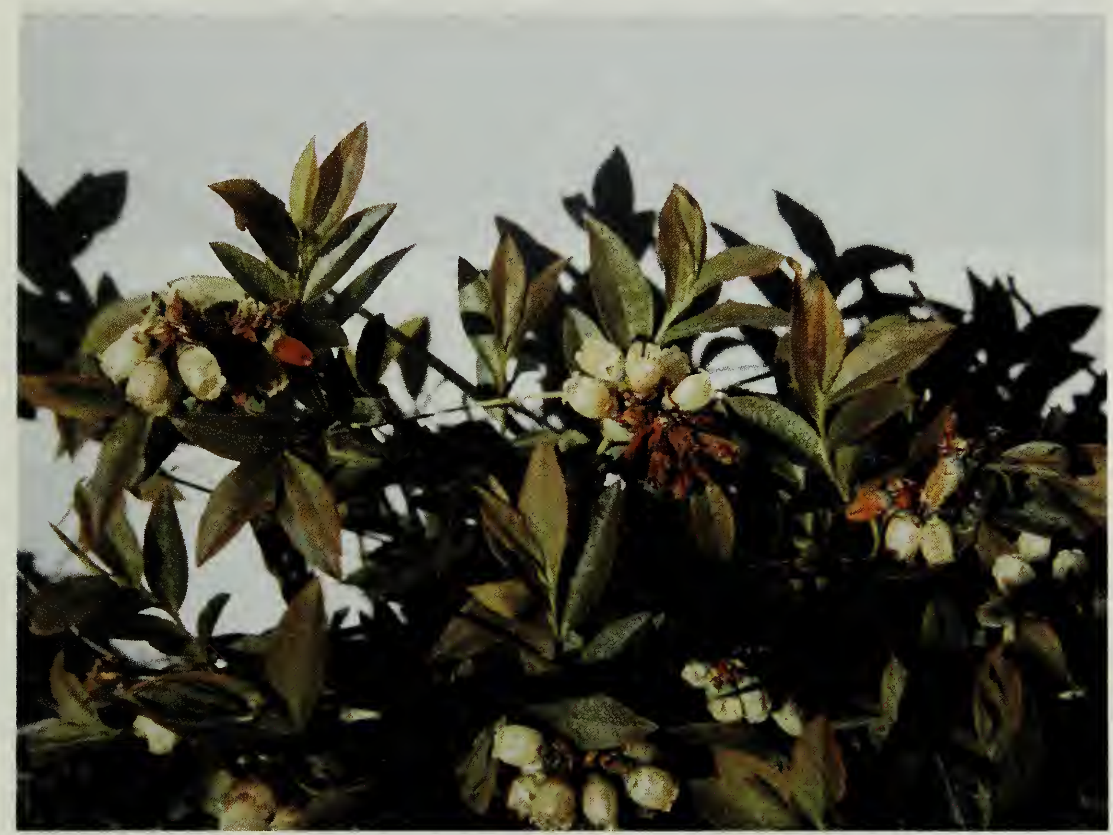


Fig. 24 Blossoms infected by botrytis blight.

Witches'-broom (*Pucciniastrum goeppertianum* (Kuehn) Kleb.)

Witches'-broom is caused by a rust fungus. Up to 6% of the plants in some fields have been found to be infected in Nova Scotia. The average for most fields is about 2%.

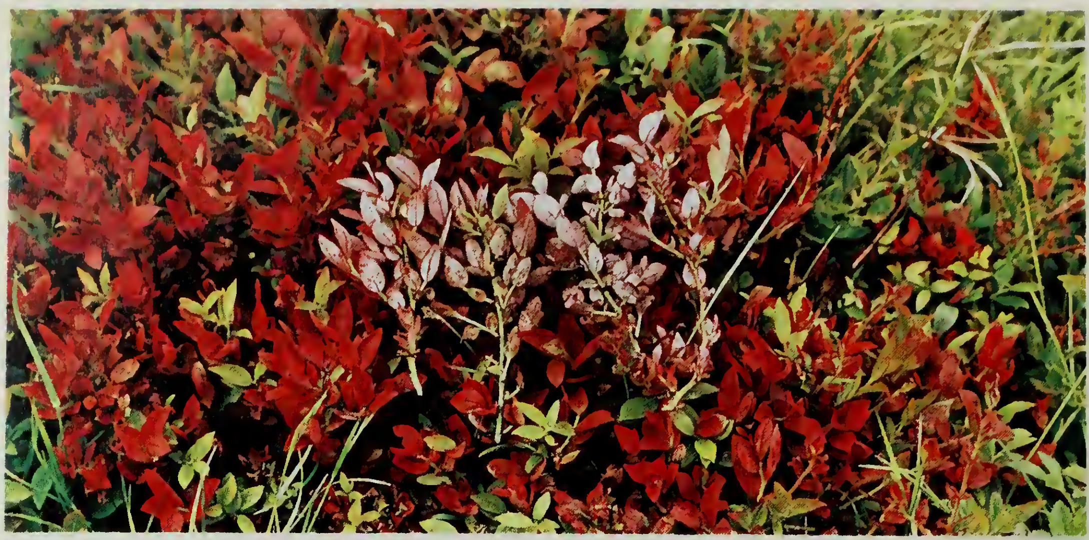


Fig. 25 Clone infected with red leaf disease. Shoots in the centre have been inverted to show white fungus mat on surface of leaves.

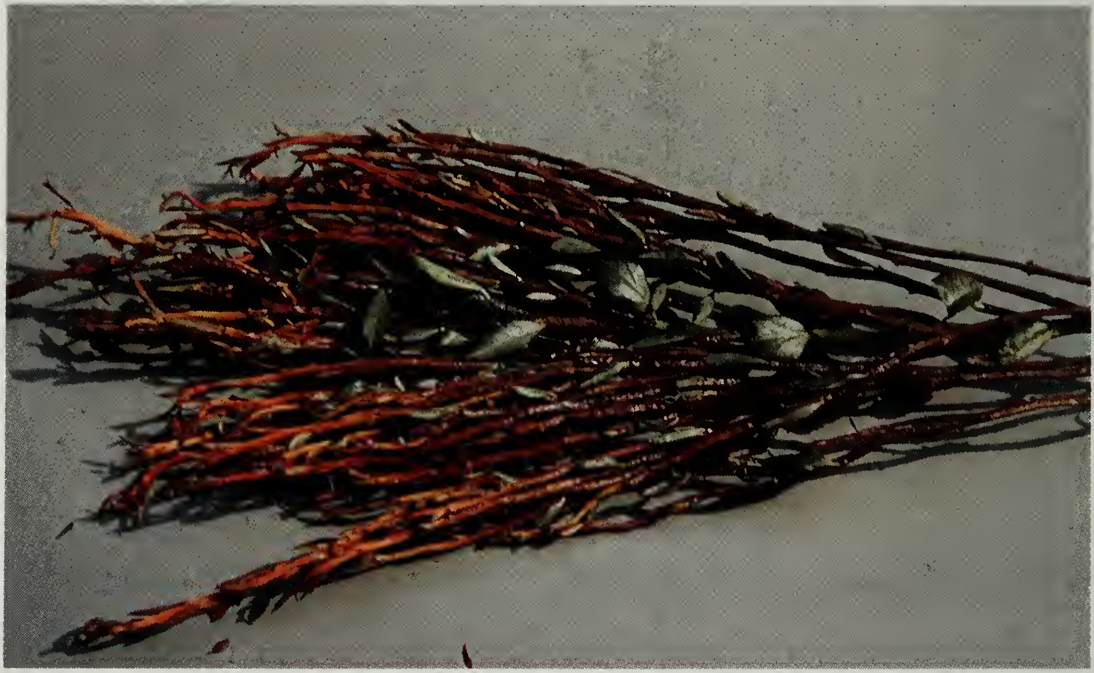


Fig. 26 Plant infected by witches'-broom.

The fungus stimulates the production of multiple shoots and a broomlike mass of swollen shoots is formed (Fig. 26). In the spring, spores produced on these shoots are carried by wind to balsam fir, where they infect the needles of the current year's growth. Another type of spore, produced in small pustules on fir needles, infects the blueberry and causes shoots to swell. The fungus growth is perennial in the blueberry and the symptoms persist until the plant dies.

Remove balsam fir trees from the vicinity of blueberry fields to reduce the incidence of witches'-broom. Burning the blueberries does not give control because infections become established in the crowns of the plants.

Witches'-broom can be controlled by grubbing out diseased plants in late autumn or early May, before spores are produced on affected shoots. All affected plants must be destroyed immediately by burning.

OTHER BLUEBERRY DISEASES

Dieback (*Diaporthe vaccinii* Shear)

Dieback is caused by one or more weak parasitic fungi that attack blueberry shoot tips after they have fruited or have been exposed to winter injury. The disease is seldom serious except in fields held over for a second crop. The tops of affected shoots become light to dark brown as the dieback or canker progresses down the stem (Fig. 27). Affected shoots are very prominent in the second-crop year. On vigorous shoots the dieback stops above fruiting twigs of the current year, but on less vigorous shoots the disease progresses farther down the main shoot and kills the new fruit twigs.

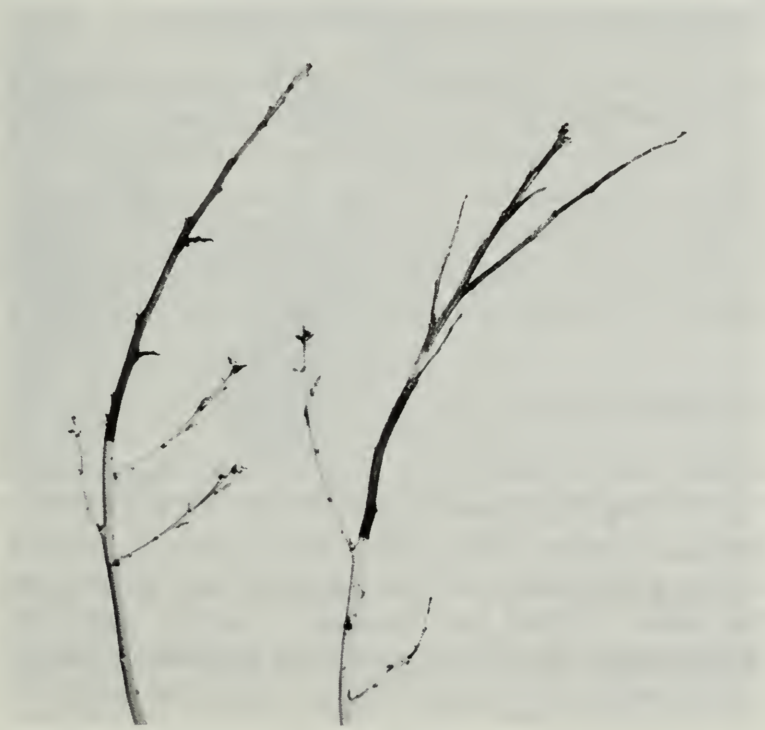


Fig. 27 Twigs infected by dieback.

When dieback becomes troublesome in a lowbush blueberry field, burn the field in alternate years.

Godronia canker (*Godronia cassandrae* Peck f. *vaccinii* Groves)

Godronia stem canker is caused by a fungus, which has been found recently on the lowbush blueberry. The cankers have a reddish border with a grayish or slightly yellow centre. The canker completely girdles the stem, killing the top section (Fig. 28). Black fruiting bodies of *Godronia* (Fig. 28, *inset*) appear in the spring on dead stems. This disease is serious on old plants, but canker is controlled in commercial blueberry fields by burning every other year.

Powdery mildew (*Microsphaera penicillata* (Wallr. ex Fr.) Lèv. var. *vaccinii* (Schw.) W.B. Cke.)

In hot and dry seasons powdery mildew can cause reddening of the leaves and defoliation in August or early September. Reddish areas appear on the leaves where the fungus has invaded, usually on the upper surface of the leaves but sometimes on the undersurface. The fungus is usually not visible without the aid of a hand lens. The leaves turn red before falling and can be readily distinguished from leaves infected with red leaf disease by the lack of a white mat on their lower surfaces.

Powdery mildew is seldom serious enough to warrant control measures.

Leaf rust (*Pucciniastrum vaccinii* (Wint.) Jorstad)

Leaf rust is a disease caused by a rust fungus that passes part of its life cycle on hemlock and part on lowbush blueberry. Leaf rust causes little damage. Affected blueberry leaves have light green areas on upper surfaces in September. On the under surface of these light green areas, rust-colored pustules of spores develop in September or later. Partial or complete defoliation occurs after harvest time, when rust is abundant. Hemlock is the alternate host of the rust.

Septoria leaf spot (*Septoria* sp.)

Septoria leaf spot, caused by a fungus, is of minor importance on the blueberry. Irregular brown spots with white centres appear on affected leaves in August (Fig. 29). Small, black, raised dots, the spore-producing structures of the fungus, are scattered over the surface of the spots. When the disease is severe, defoliation occurs, mainly in scattered patches throughout the blueberry field.

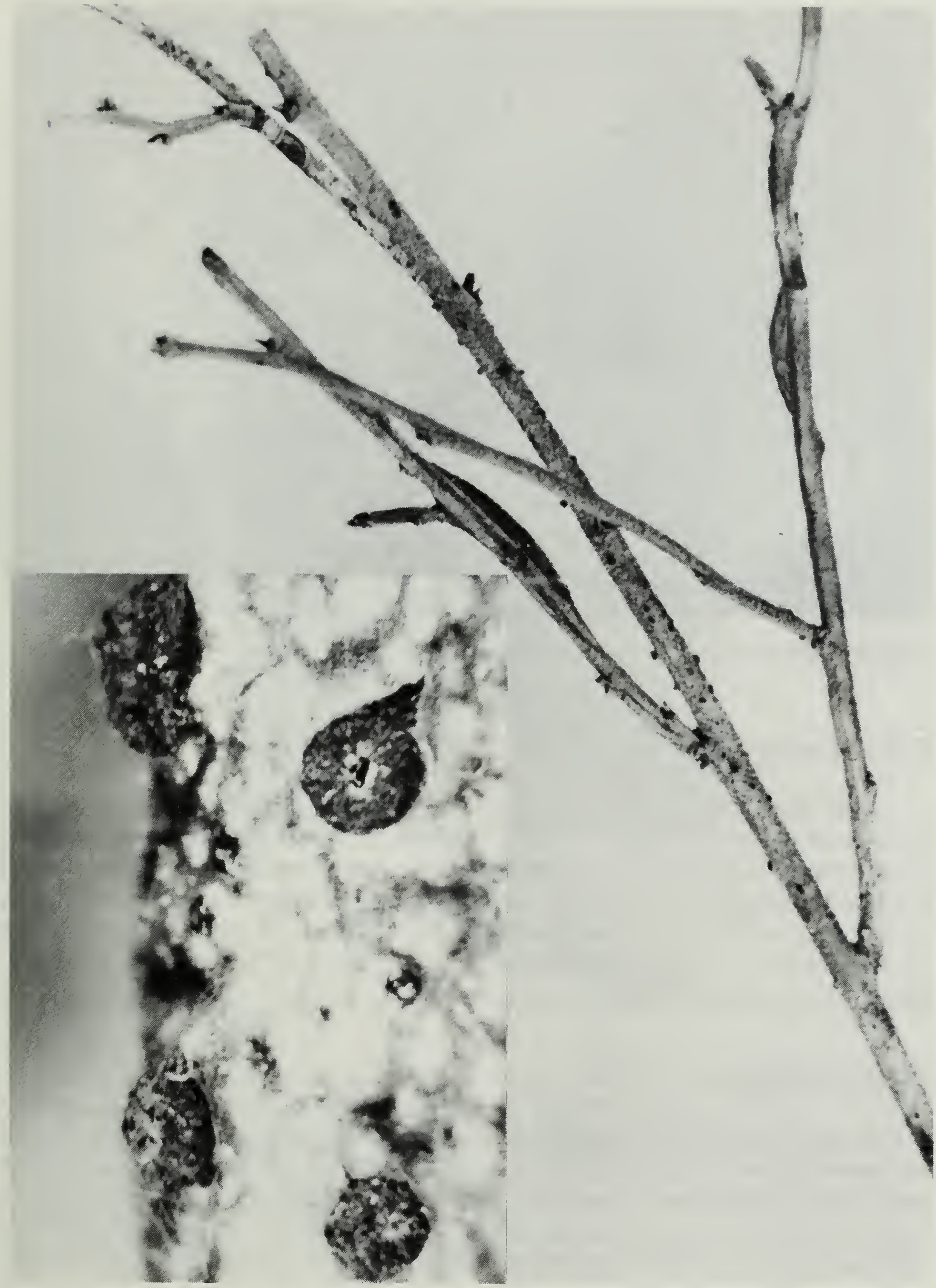


Fig. 28 **Dead shoot infected by *Godronia*. *Inset*, apothecia on blueberry stem.**

Gloeosporium leaf spot (*Gloeosporium minus* Shear)

Gloeosporium leaf spot is also caused by a fungus, which produces a circular, brown to black spot with white growth of the fungus showing on the lower surface of the leaf. The disease is rarely found on the lowbush blueberry.

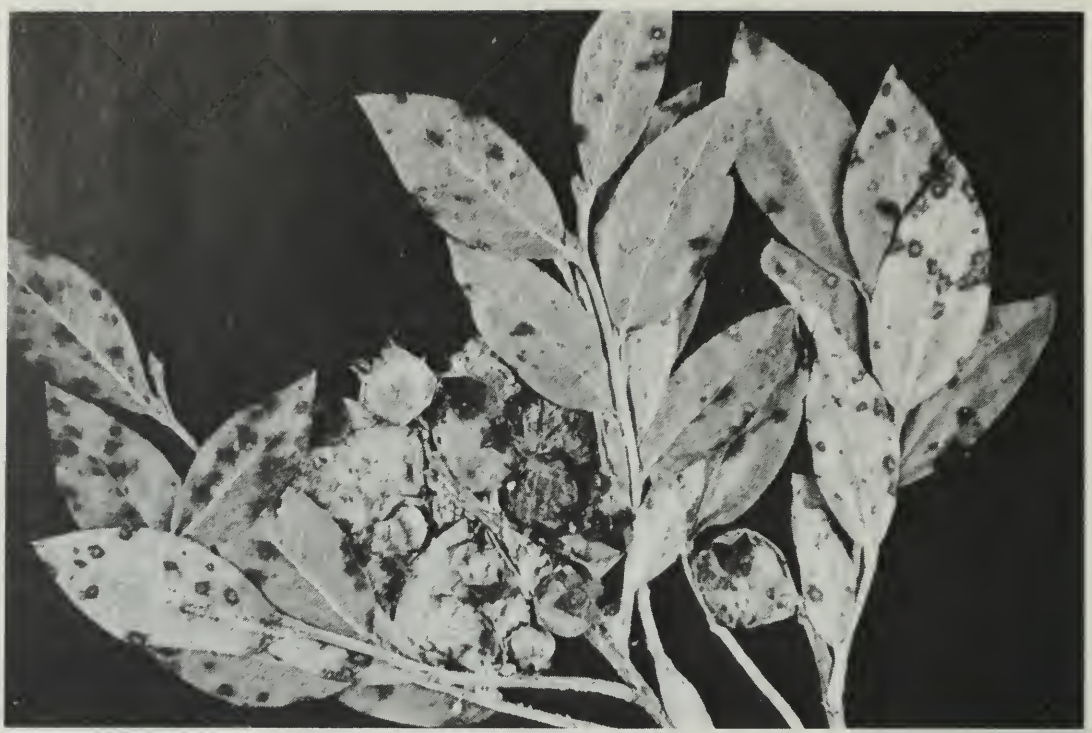


Fig. 29 Leaves infected by *septoria* leaf spot.

Other leaf spots

Leaf spotting of unknown causes occurs on lowbush blueberries during midsummer and is more severe in crop years. The spotting occasionally appears in the sprout year. Leaf spotting is more severe during prolonged dry weather or where blueberries are grown on light sandy or gravelly soils. Unshaded leaves show more injury than those in the shade. Some leaf spotting is caused by plant viruses. Defoliation occurs if spotting is severe.

FROST INJURY

Vegetative buds in early stages of development may be damaged by spring frosts (temperatures below −2°C). The injury results in death of tissues inside the bud. Subsequent growth of the bud results in a rosette of leaves consisting of the blackened centre of the bud surrounded by a few expanded leaves, which previously were the outermost leaves of the bud (Fig. 30). Extensive frost injury may adversely affect yields as less vegetative growth occurs to support fruit production. Flower buds do not appear to be susceptible to frost during early stages of development but become sensitive during bloom.

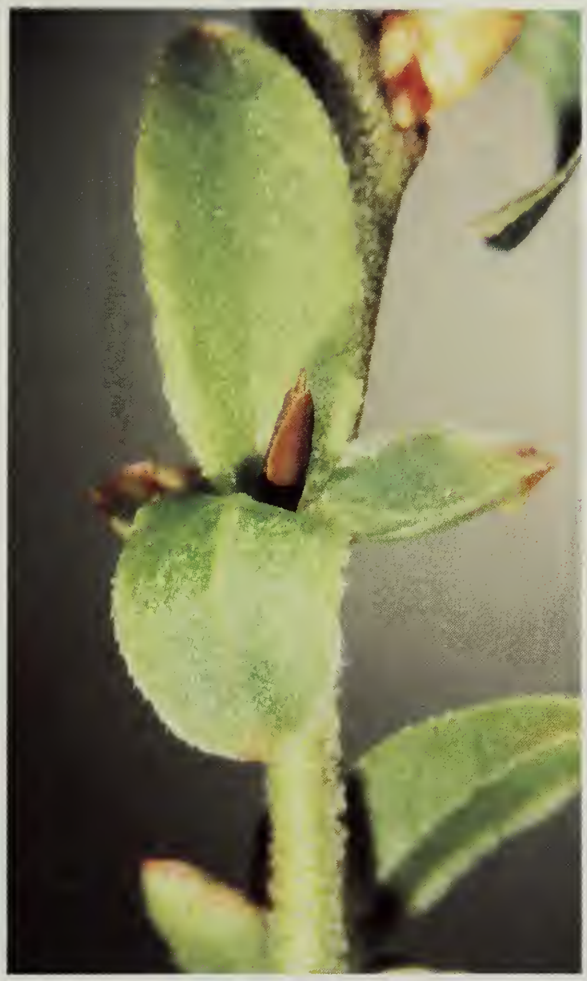


Fig. 30 Frost injury of a vegetative bud.

WINTER INJURY

Winter injury occurs during the winters of light snowfall resulting in exposure of blueberry stems above the snow line. Injury may be observed on the upper portions of stems where buds and stem tissues appear shrivelled. Stem tissues appear gray to dark brown. Buds on injured portions of stems fail to develop when growth begins in spring.

HARVESTING AND STORAGE

R.K. Prange and P.D. Lidster

HARVESTING

As blueberries ripen very little after harvest, they are not picked until they have reached full maturity. The full maturity of blueberries is often determined by the change of fruit color from green to black, which results from the darkening of the epidermis. Mature fruit may actually appear light blue because of the presence of a waxy bloom on the epidermis. Removal of the waxy bloom by abrasion, handling, or senescence results in the perception of darker berries. At optimum harvest the berries are firm and have a high sugar and an acceptable acid content.

Blueberries are generally picked with hand rakes or mechanical harvesters and are placed in plastic, two-compartment field containers (41 × 51 × 14 cm) that can hold about 10 kg. The most serious problem is physical damage to the berries caused by excessive clumping in the hand rakes or rough handling of the berries in the field. The berries should be raked from the plants carefully to avoid crushing and handled gently to avoid bruising or dropping when being placed in field containers. The depth of blueberries in the container should be shallow enough to avoid crushing both those in the lower layers and those on top that might contact the containers above. Mechanical harvesters may cause less physical damage than hand raking especially where the field is relatively level and the blueberry stand is weed free. Overmature or warm berries are softer, which makes them more susceptible to physical damage.

It is important to keep the berries cool during harvest. The warmer the berries at time of harvest, the faster they deteriorate. Berries harvested during the middle of the day when temperatures are greatest deteriorate faster than those harvested early in the morning or in the evening. Both empty and full field containers should be shaded to keep them as cool as possible.

Although it is preferred that berries should be harvested dry, there is little evidence to show that wet berries are a major cause of postharvest loss due to fungal decay.

CLEANING AND GRADING

Harvested blueberries can contain foreign matter and poor-quality berries that must be removed. Mechanical harvesters generate an air stream that removes most of the leaves and other light foreign material. Further cleaning and grading is usually done at centralized facilities.

Blueberries destined for the fresh market are usually processed in the following sequence:

- Air cleaning—Berries are passed over a vertical air stream that removes the light foreign material (Fig. 31).
- Size grader—Berries are separated according to diameter, which removes most of the green and undersized ripe berries. Most size graders use calibrated openings to remove the undersize berries.
- Drier—Berries are dried on a mesh belt, which is passed over a vertical air stream that may be heated or dehumidified.
- Tilt bed separator—Good berries are separated from clumped berries and other material by a tilted conveyor belt running perpendicular to the flow of berries. The good berries, which generally roll more, fall off on to a flat conveyor belt running below the tilted belt (Fig. 32).
- Manual grading and packaging—The remaining berries are inspected visually before they drop off the conveyor belt into commercial containers. The container weight is checked and a cellophane sheet or woven net is placed over the container to control movement of the berries. The recommended commercial package is a 0.57 L (1 pint) pulp container held in a 6.8 L (12 pint) reinforced cardboard shipping box (Fig. 33). Bulk 2.27 kg (5 lb) and 4.54 kg (10 lb) boxes are also used.

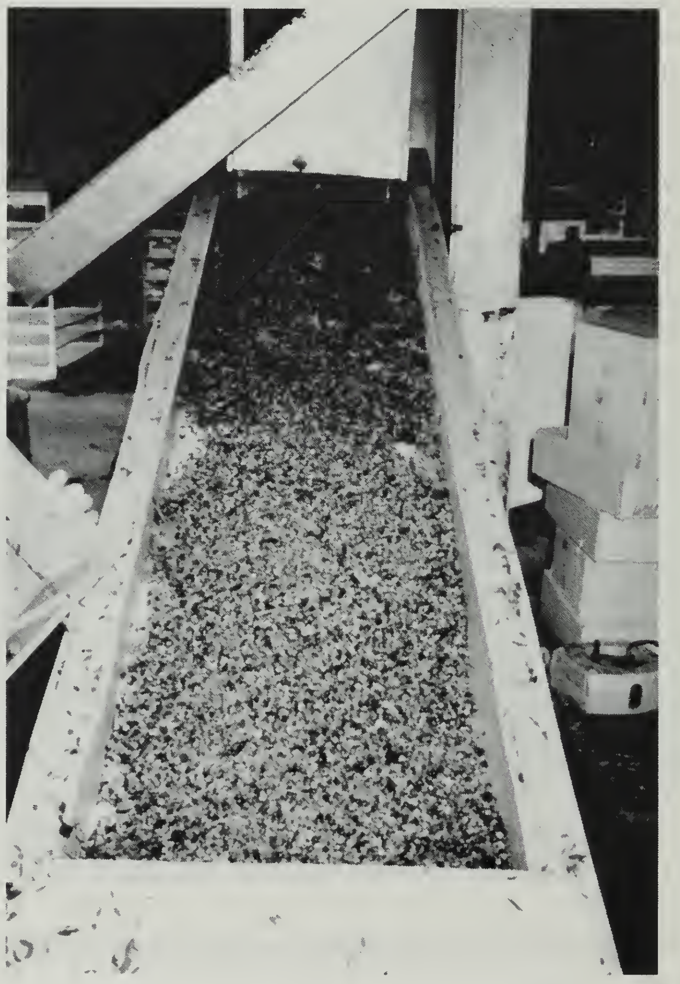


Fig. 31 Blueberries being air cleaned at a central facility.

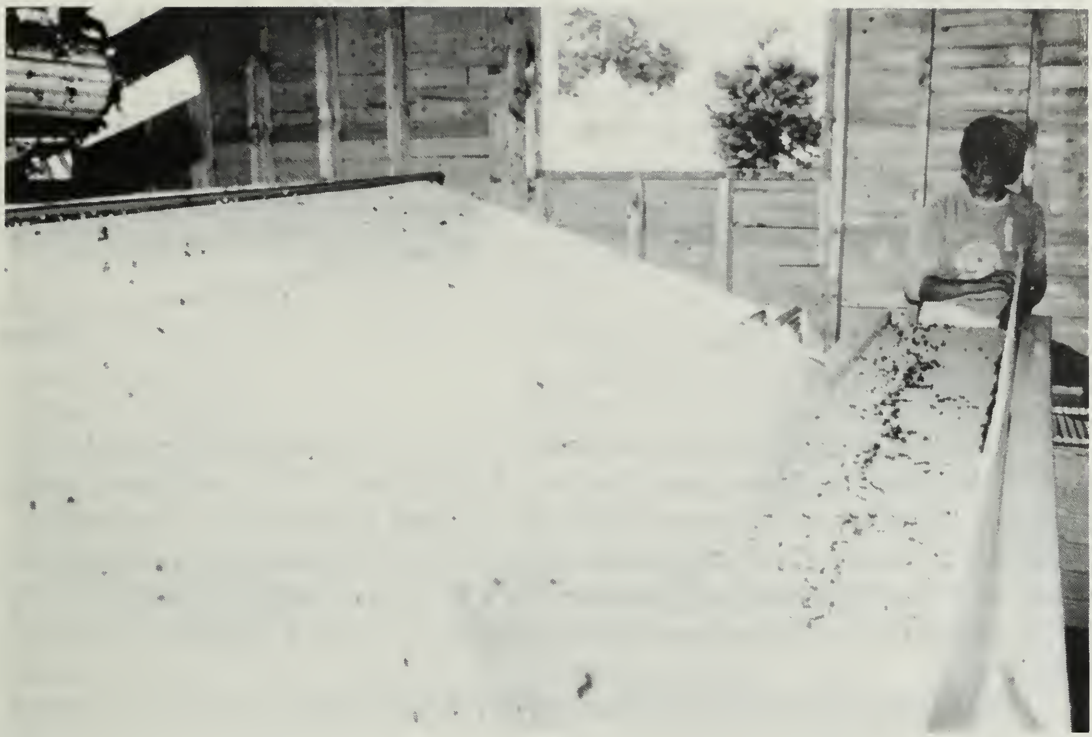


Fig. 32 A tilt bed separator.

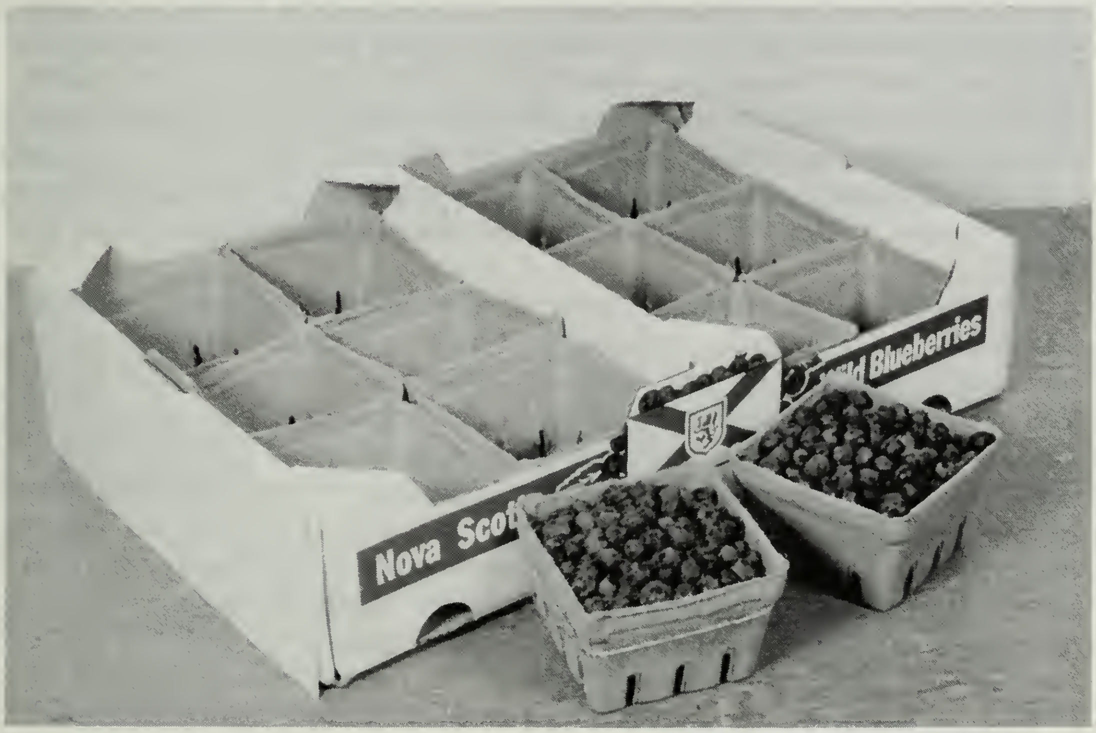


Fig. 33 The commercial package and shipping container for berries destined for the fresh market.

Technology is becoming available that can electronically size and color-grade blueberries, which may reduce the need for a mechanical size grader and a tilt bed separator.

Berries for processing can be cleaned by passing them over a vertical air cleaner and size grader The berries then drop into a water tank to wash them and to remove green berries and other materials. Ripe berries sink and are carried forward for further grading. If foreign matter is still present it can be removed by addition of a high-density bath, e.g., 18% sugar (w/v), in which ripe berries usually float and are skimmed off for grading and individual quick freezing (IQF). Frozen berries are passed through a squirrel-cage destemmer and are graded again before being packaged in 13.6 kg (30 lb) poly-lined cartons.

STORAGE

Berries should be cooled as soon as possible after harvest, ideally to O°C within 2 h of harvest (but not later than 12 h), to retain their optimum quality. The most efficient method is forced-air precooling. Palletized field containers or packaged fresh berries are placed in front of a refrigerated air stream, (0°C), which rapidly removes the field heat and cools the berries to between 0° and 4°C within several hours.

If berries need to be held for longer periods, they should be moved to an odor-free, disinfected cold room that has adequate air circulation and refrigeration capacity. The optimum storage temperature is between −0.5° and 0°C, and the optimum humidity is 90–95%. Higher humidities encourage fungal growth at higher storage temperatures, whereas lower humidities accelerate water loss and shrivelling. Berries that are free from physical damage, receive a surface sterilant or fungicide application, have a low sugar-to-acid ratio, are precooled to 0°C within several hours after harvest, and are stored at optimum humidity and temperature can have an acceptable storage life of 2–4 weeks.

The presence of surface water on berries (sweating) should be avoided when removing precooled fruit to warm temperatures. Sweating of berries can lead to loss of bloom and consequently loss of perceived freshness and can increase the incidence and severity of decay. Sweating can be avoided by wrapping of cooled flats or individual containers. Overwrapping of precooled fruit provides more gradual warming and separates the cool berries from the warm ambient air, which suppresses water formation on the berry surfaces. Note that fruit sweating may occur on the inside of the overwrap if warm fruit is placed in refrigerated temperatures.

If the berries are cooled promptly to 0°C, modest additional storage life can be achieved by controlling the atmospheric concentration of oxygen and carbon dioxide. Respiration can be slowed if oxygen is reduced to 1–5%, and decay can be reduced by increasing carbon dioxide up to 15–20%.

Frozen blueberry cartons should be stacked to allow cold air circulation and should be stored at −18°C or lower. Under these conditions acceptable quality in frozen blueberries can be maintained for up to 2 years. Thawed berries should not be refrozen.

SCIENTIFIC NAMES

Insects

black army cutworm	*Actebia fennica* (Tauscher)
blueberry case beetle	*Neochlamisus cribripennis* (LeConte)
blueberry flea beetle	*Altica sylvia* Malloch
blueberry leaf beetle	*Pyrrhalta vaccinii* (Fall)
blueberry leaftier	*Croesia curvalana* (Kearfott)
blueberry maggot	*Rhagoletis mendax* Curran
blueberry spanworm	*Itame argillacearia* Packard
blueberry thrips	*Frankliniella vaccinii* Morgan *Catinathrips kainos* O'Neill
blueberry tip midge	*Contarinia vaccinii* Felt
chainspotted geometer	*Cingilia catenaria* (Drury)
fruittree leafroller	*Archips argyrospilus* (Walker)
grasshoppers	*Melanoplus* sp. *Camnula pellucida* (Scudder)
redstriped fireworm	*Aroga trialbamaculella* (Chambers)
sawflies	*Neopareophora litura* (Klug) *Pristiphora idiota* (Norton) *Pristiphora* sp.
small leaf chafer	*Serica tristis* LeConte
stem gall	*Hemadas nubilipennis* (Ashmead)
whitemarked tussock moth	*Orgyia leucostigma* (J.E. Smith)

Diseases

botrytis blight	*Botrytis cinerea* Pers.
dieback	*Diaporthe vaccinii* Shear
gloeosporium leaf spot	*Gloeosporium minus* Shear
godronia canker	*Godronia cassandrae* Peck f. *vaccinii* Groves
leaf rust	*Pucciniastrum vaccinii* (Wint.) Jorstad
monilinia blight	*Monilinia vaccinii-corymbosi* (Reade) Honey
powdery mildew	*Microsphaera penicillata* (Wallr. ex Fr.) Lèv. var. *vaccinii* (Schw.) W.B. Cke.
red leaf	*Exobasidium vaccinii* Wor.
septoria leaf spot	*Septoria* sp.
witches'-broom	*Pucciniastrum goeppertianum* (Kuehn) Kleb.

Weeds

alder	*Alnus rugosa* (Du Roi)
Allegheny serviceberry (wild pear)	*Amelanchier laevis* Wieg.
aspen poplar (trembling aspen)	*Populus tremuloides* Michx.
bayberry	*Myrica pensylvanica* Loisel.
black chokeberry	*Pyrus melanocarpa* (Michx.) Willd.
broad-leaved meadowsweet	*Spiraea latifolia* (Ait.) Borkh.
bunchberry	*Cornus canadensis* L.
bush-honeysuckle	*Diervilla lonicera* Mill.
Canadian rhododendron	*Rhododendron canadense* (L.) Torr.
common juniper	*Juniperus communis* L.
eastern bracken	*Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw.
gray birch	*Betula populifolia* Marsh.
hardhack	*Spiraea tomentosa* L.
hay-scented fern	*Dennstaedtia punctilobula* (Michx.) Moore
pearly everlasting	*Anaphalis margaritacea* (L.) Benth. & Hook.
sheep-laurel	*Kalmia angustifolia* L.
sweet-fern	*Comptonia peregrina* (L.) Coult.
wild rose	*Rosa carolina* L.
willow	*Salix* spp.
withrod	*Viburnum cassinoides* L.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in	
Length			
inch	× 25	millimetre	(mm)
foot	× 30	centimetre	(cm)
yard	× 0.9	metre	(m)
mile	× 1.6	kilometre	(km)
Area			
square inch	× 6.5	square centimetre	(cm^2)
square foot	× 0.09	square metre	(m^2)
acre	× 0.40	hectare	(ha)
Volume			
cubic inch	× 16	cubic centimetre	(cm^3, mL, cc)
cubic foot	× 28	cubic decimetre	(dm^3)
cubic yard	× 0.8	cubic metre	(m^3)
fluid ounce	× 28	millilitre	(mL)
pint	× 0.57	litre	(L)
quart	× 1.1	litre	(L)
gallon	× 4.5	litre	(L)
Weight			
ounce	× 28	gram	(g)
pound	× 0.45	kilogram	(kg)
short ton (2000 lb)	× 0.9	tonne	(t)
Temperature			
degrees Fahrenheit	(°F − 32) × 0.56 or (°F − 32) × 5/9	degrees Celsius	(°C)
Pressure			
pounds per square inch	× 6.9	kilopascal	(kPa)
Power			
horsepower	× 746	watt	(W)
	× 0.75	kilowatt	(kW)
Speed			
feet per second	× 0.30	metres per second	(m/s)
miles per hour	× 1.6	kilometres per hour	(km/h)
Agriculture			
gallons per acre	× 11.23	litres per hectare	(L/ha)
quarts per acre	× 2.8	litres per hectare	(L/ha)
pints per acre	× 1.4	litres per hectare	(L/ha)
fluid ounces per acre	× 70	millilitres per hectare	(mL/ha)
tons per acre	× 2.24	tonnes per hectare	(t/ha)
pounds per acre	× 1.12	kilograms per hectare	(kg/ha)
ounces per acre	× 70	grams per hectare	(g/ha)
plants per acre	× 2.47	plants per hectare	(plants/ha)